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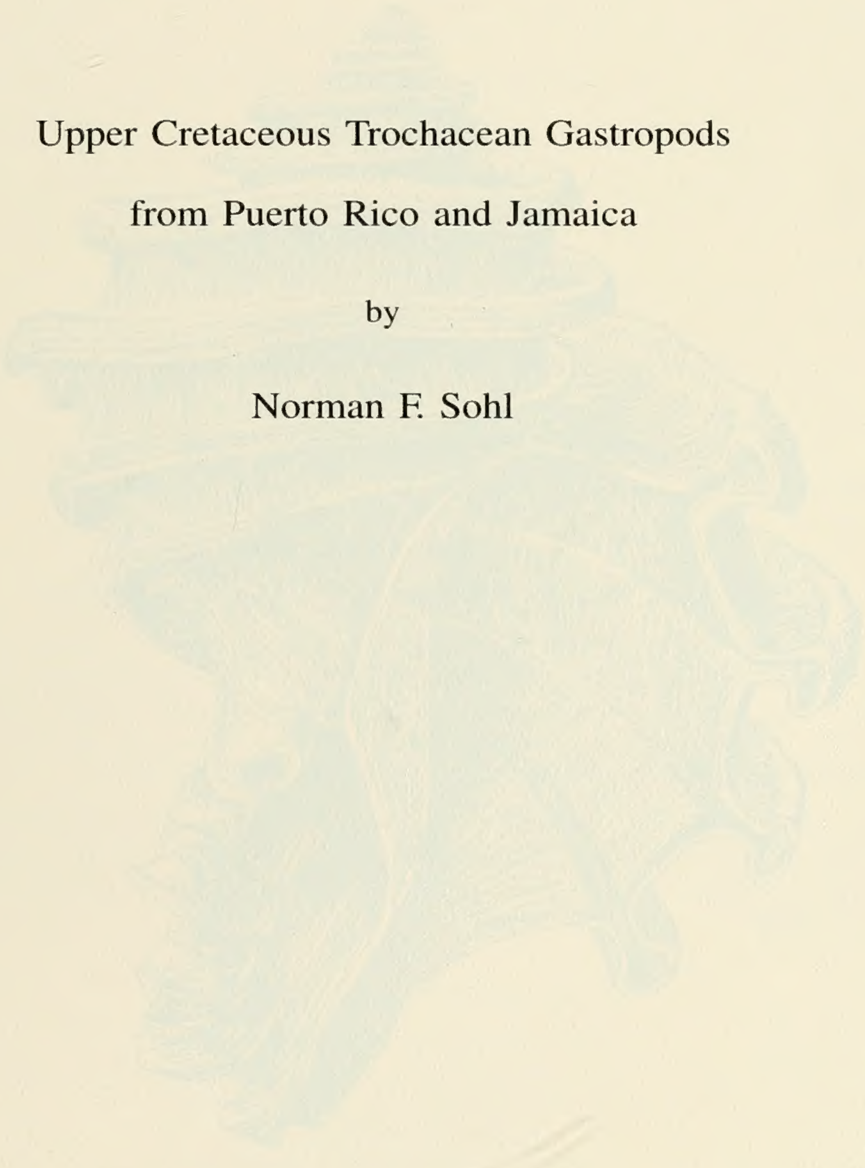

Upper Cretaceous Trochacean Gastropods from Puerto Rico and Jamaica

by

Norman F. Sohl

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FOREWORD

G. LYNN BREWSTER-WINGARD

U.S. Geological Survey
Reston, Virginia 22092

Norman F. Sohl died on April 14, 1993. In December of 1992, he had completed the posttechnical review copy of his manuscript and had forwarded it for U.S. Geological Survey (USGS) publication approval. In May 1993, I was asked to serve as the author's representative through the remainder of the publication process. In 1995, the manuscript was withdrawn from the USGS publishing process and submitted to PRI for publication.

In preparing the manuscript for publication, I reviewed the copy, addressing questions raised by the editor and by myself, to ensure consistency and accuracy in the final report. Norm's field notes, maps, and collections were used to answer objective questions wherever possible, but some interpretations had to be made. Every attempt was made to remain true to the author's original intent, but I accept responsibility for, and apologize for, any errors introduced in this process. Inconsistencies in locality and collection information with an earlier publication (Sohl and Kollmann, 1985, USGS Professional Paper 1304) were discovered, but, because the information contained herein was tracked back to the original data, I believe this publication to be correct. No changes were made to the subjective elements of the taxonomic or interpretive sections of the paper, and I have avoided changes that would have altered Norm's substance or style. I believe this published paper is a valid representation of the finished product Norm himself would have produced.

UPPER CRETACEOUS TROCHACEAN GASTROPODS FROM PUERTO RICO AND JAMAICA

NORMAN F. SOHL[1]
U. S. Geological Survey
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ABSTRACT

During the Cretaceous, trochacean gastropods were common elements in the shallow warm-water faunas of the Tethyan Realm. In the Caribbean region, they were especially abundant in the lagoonal facies associated with the rudist framework ("reef") tracts of the widespread carbonate-platform deposits, but some also lived in shallow shelf environments. Most of the more common trochacean species in the lagoonal facies belong to long-lived genera originating in the "corallien" or reef-associated faunas of the Jurassic, whereas many of those from the shelfal deposits are of Cretaceous origin. The greater diversity and individual abundance of trochacean gastropods in the lagoonal deposits are judged to reflect the presence of more suitable habitats. Abundant rubble and bioclastic debris, derived from the destruction of patch reefs and associated rudist bivalve organic framework structures, provided firm substrates suitable for colonization by trochaceans. The warm shallow water of these lagoons also probably provided optimum areas for growth of algae, a major food source for trochaceans.

Some trochacean genera of Jurassic ancestry, such as *Chilodonta* and *Discotectus,* show shifts in basic morphology late in their Upper Cretaceous stratigraphic ranges. In *Chilodonta,* modifications of the aperture margin and an increase in its inclination to the growth axis provide a conical form, suggesting adaptation to a clinging habit. Modifications in morphology of derivatives of *Discotectus* and *Tectus* are also discussed, and a general survey of Cretaceous Trochacea occurrence is given. Of special note is the presence in the collections studied of specimens assigned to *Metriomphalus* Cossmann, 1916[a], that preserve the operculum in place. The character of the operculum suggests placement of this long-ranging (Jurassic through Eocene(?)) genus in the Colloniinae rather than the Angariinae.

A section of the report, "Stratigraphy and Locality Register," includes stratigraphic reassessment of the Santonian to Maastrichtian rocks in which the described gastropods are found. These carbonate-platform fossiliferous limestones and shales occur only sporadically within the much thicker sections of primary volcanic rocks, pyroclastic materials, coarse volcaniclastic sediments, and other deposits characteristic of a volcanic arc system. Typical stratigraphic sections are presented along with lists of accompanying mollusks and maps showing the location of the 79 collecting localities, with the exception of localities 66–68; no base maps are available for these three localities because of cloud cover recorded on images from which maps would have been made.

The "Systematic Paleontology" section of this report consists of the description of 29 new species and eight indeterminant taxa. No formal description is given for the eight indeterminant taxa because either too few specimens were found or the material is too poorly preserved to provide a basis for formal description. These species are assigned to 16 genera, among which *Antillocollonia* is described as new and assigned to the subfamily Colloniinae, and *Denticulabrum* and *Stegnostomella* are described as new and assigned to the subfamily Trochinae. *Micatia* is proposed as a subgenus of *Camitia* of the subfamily Umboniinae. The following 29 species are described as new: *Pseudoliotina mcleani, Arene truncatosphaera, Nododelphinula trechmanni, Nododelphinula? nudula, Antillocollonia brujoenisis, Metriomphalus woodringi, Metriomphalus horridus, Metriomphalus canabonensis, Chilodonta obliqua, Chilodonta jamaicaensis, Planolateralus? hanoverensis, Discotectus coquiensis, Discotectus barranquitasensis, Discotectus gelaberti, Discotectus cyrtoconus, Discotectus scotti, Discotectus crebrinodosus, Discotectus zansi, Discotectus marchmontensis, Denticulabrum laevigatum, Denticulabrum duckettsensis, Stegnostomella haughtonensis, Tectus revesensis, Tectus berryhilli, Tectus kauffmani, Tectus variegatus, Jujubinus botijasensis, Solariella marchmontensis,* and *Camitia (Micatia) plicata.* The large percentage of species described as new is a reflection both of the lack of previously published descriptions of gastropods from the Caribbean province and of the increased endemism of the fauna during the latest Cretaceous.

INTRODUCTION

Knowledge of the Cretaceous molluscan faunas of the Greater Antilles has evolved slowly since the early descriptive reports of rudist bivalves by Woodward in 1862. Subsequent works by Whitfield (1897), Trechmann (1922, 1924), Douvillé (1926, 1927), Palmer (1933), Rutten (1936), Thiadens (1936), MacGillavry (1937), Vermunt (1937), Torre (1960), Chubb (1971), Dommelen (1971), Kauffman and Sohl (1974), and others have provided a solid framework for the assessment of the taxonomic composition and mode of occurrence of rudist bivalves in the Caribbean province.

Development of information pertaining to the other groups of mollusks has not kept pace with that for the rudists. For example, until 1985, few species of gastropods had been described from the Cretaceous of the Antillean Islands and those only as adjuncts to the study of larger faunal assemblages (for example, Trechmann, 1927) or biostratigraphic resolution of geologic problems (Sohl, 1968, 1976). Two papers by

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[1] Deceased, April 14, 1993.

Sohl (1971, 1987) have dealt with paleozoogeographic, compositional, and other general aspects of the Cretaceous Caribbean gastropod assemblages, but the first systematic study of a significant element of the fauna did not appear until 1985 and dealt with the cephalaspidean opisthobranch family Actaeonellidae (Sohl and Kollmann, 1985). That study was followed by description of the archaeogastropod groups Fissurellidae, Haliotidae, and Scissurellidae (Sohl, 1992). The study of the Trochacea presented here completes the survey of the Upper Cretaceous archaeogastropods of Puerto Rico and Jamaica.

Much of the material reported on here was collected during the U.S. Geological Survey-Commonwealth of Puerto Rico cooperative program of mapping of Puerto Rico (1956–74). Concurrently, the author and others were involved in Cretaceous stratigraphic studies on the island of Jamaica (1966–71) that provided the remainder of the collections. The complete collections made during these times are currently housed at the National Museum of Natural History, Washington, D.C., and at the National Headquarters of the U.S. Geological Survey, Reston, Va.

ACKNOWLEDGMENTS

By N.F. Sohl.—Both Carole S. Hickman, Museum of Paleontology, University of California at Berkeley, and James H. McLean, Natural History Museum of Los Angeles County, kindly shared their great knowledge of trochacean gastropods. When I was at the University of the West Indies, Kingston, Jamaica, Ted Robinson was especially helpful in providing maps, hospitality, and aid in arranging the shipping of collections. Anthony G. Coates, Smithsonian Tropical Research Institute; J.E. Hazel, Louisiana State University; E.G. Kauffman, University of Colorado at Boulder; and H.A. Kollmann, Natural History Museum, Vienna, Austria, aided in the collection of some of the fossils and in pertinent discussion of stratigraphic problems in the field and office. Others who assisted in collecting specimens are named in the locality descriptions. G. Lynn Wingard and Marija Balanc, both of the U.S. Geological Survey (USGS), did the photography and preliminary drafting of the figures. The report was improved by reviews by Robert B. Blodgett (USGS) and G. Lynn Wingard.

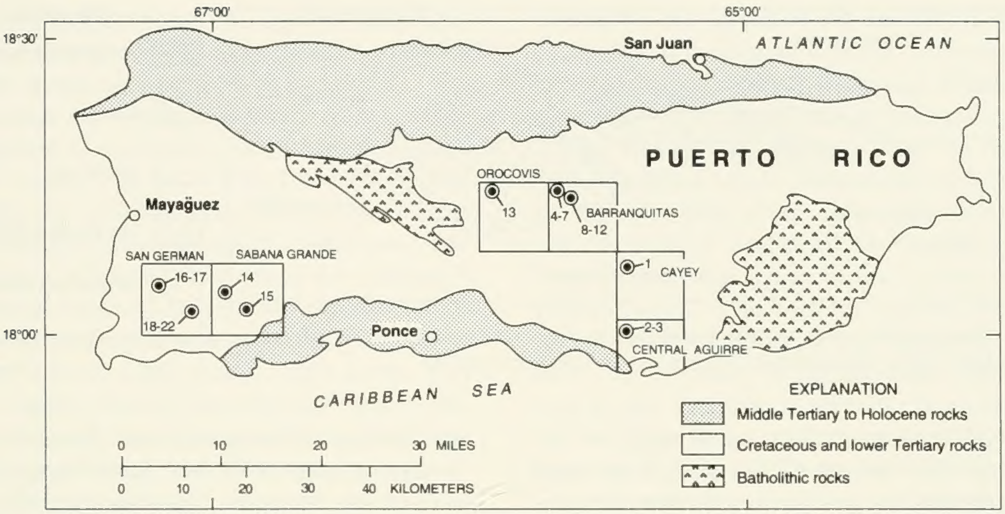
By G.L. Brewster-Wingard.—The number of people who assisted me in the process of seeing this publication through to completion is a testament to Norm Sohl's standing among his colleagues. The efforts of David Jablonski, University of Chicago, in examining the manuscript with me for consistency, in addressing the editor's questions, and in tracking down obscure references were invaluable. Anthony G. Coates, Smithsonian Tropical Research Institute, contributed to the resolution of several of the stratigraphic and field locality questions and saved me weeks of research time. A number of people assisted in completing the reference list: Susan M. Kidwell, University of Chicago; Rüdiger Bieler, Field Museum of Natural History; Neil H. Landman, American Museum of Natural History; Stephen K. Donovan, University of the West Indies; Kaustov Roy, University of Chicago; and Scott Lidgard, Field Museum of Natural History.

GEOLOGIC SETTING

Upper Cretaceous deposits are present on all the islands of the Greater Antilles. In Puerto Rico, they compose a major part of the mainly east-trending cordillera as well as minor ranges along the southern foothills and Coastal Plains of the island (Text-fig. 1). In central and western Jamaica (Text-fig. 2), Cretaceous deposits are exposed mainly in a series of inliers separated by large areas of Tertiary cover. The Upper Cretaceous deposits are also exposed in a series of structurally complex outcrops in the Blue Mountains in eastern Jamaica, which were described by Krijnen and Lee Chin (1978); the outcrops in eastern Jamaica are not treated here, as none of the studied fossils came from that area.

On the islands of Puerto Rico and Jamaica, sequences of Upper Cretaceous carbonate-platform, fossiliferous limestones and shales are volumetrically subordinate to volcaniclastic sediments. Commonly, these fossiliferous units record local periods of volcanic quiescence within the island-arc system that were of sufficient length to allow establishment of rudist "reef" communities or other shelfal biofacies. As pointed out by Coates (1977), such a pattern conforms to the model proposed by Dickinson (1974) for sedimentation within magmatic arcs. Within this framework, an arc magmatic complex forms the core element (Text-fig. 3) and is flanked by back-arc and inter-arc basins. Two primary facies have been distinguished within these marginal basins and named by Dickinson (1974) as the central facies and the dispersal facies. The central facies is deposited near the active vent centers and consists dominantly of coarse volcaniclastic material, breccias, conglomerates, lava flows, and ash flows. Biogenic reefs may develop on the flanks of inactive cones in this facies (Glover, 1971, fig. 10), but more common in the Antilles are interbedded red beds or marginal marine sediments containing brackish-water fossils. Examples of such deposits are discussed below for the Orocovis quadrangle of Puerto Rico and the Marchmont inlier of Jamaica. Coates (1977) has noted other Jamaican examples.

Most of the fossiliferous deposits discussed here ap-

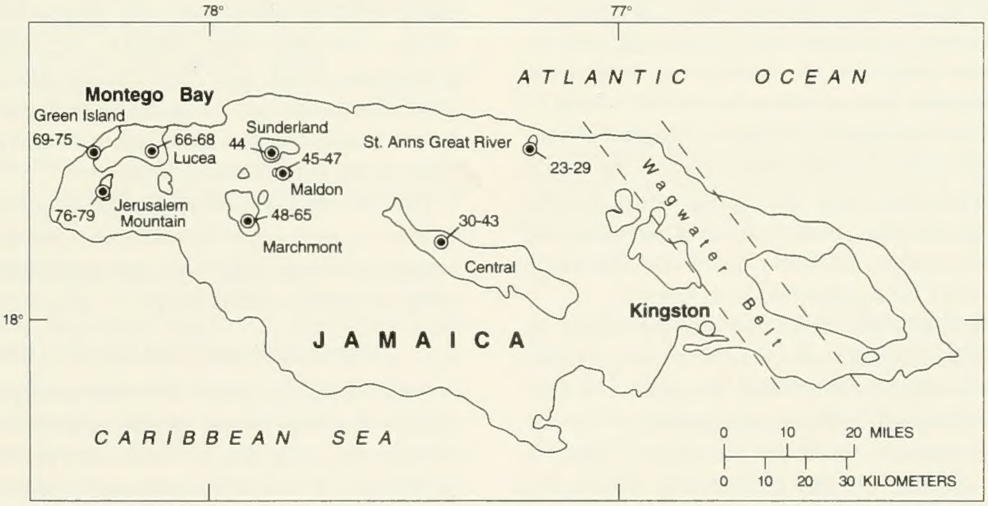


Text-figure 1.—Collection localities and selected geologic units in Puerto Rico. Numbers in labeled 7.5-minute quadrangles refer to localities described in "Stratigraphy and Locality Register." Modified from Glover (1971) and Sohl (1992).

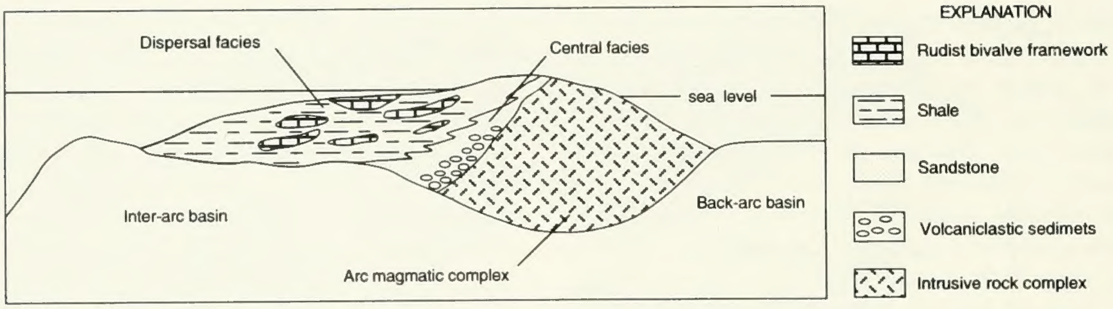
pear to lie within the limits of the dispersal facies (Text-fig. 3). In general, such deposits are regularly bedded and overall finer grained than the central facies and consist of marine tuffs, sandstones, shales, and limestones. During favorable time intervals (Kauffman and Sohl, 1974; Scott, 1984), organic frameworks, dominated by rudist bivalves, developed in shallow-water areas. Most such carbonate-platform units are relatively thin and measure less than a few tens of meters; they may be tabular, grading laterally into shale or rubble units. Cessation of growth of these organic structures is usually marked by caps of volcaniclastic sediments that indicate new episodes of volcanic activity in the area.

CRETACEOUS TROCHACEA

The time of origin of the Trochacea is currently equivocal. Some authors (Wenz, 1938; Knight *et al.*, 1960) favor a Triassic origin. McLean (1982) extended this range to the Permian by recognizing *Dichostasia* Yochelson, 1956, as a member of the Liotiinae. Earlier, Cossmann (1918) accepted a Silurian origin for the Trochidae as he viewed them, but the Paleozoic taxa Cossmann cited were subsequently removed to the



Text-figure 2.—Collection localities and main exposures of Cretaceous rocks (unpatterned areas) in Jamaica. Numbers on map refer to localities described in "Stratigraphy and Locality Register." Fossil trochaceans described in this report were collected from labeled inliers in central and western Jamaica. The Wagwater Belt is a subduction complex between the Blue Mountains on the east and the carbonate platform on the west.



Text-figure 3.—Diagrammatic cross section showing postulated areas of deposition within the Caribbean Cretaceous island-arc system (modified from Coates, 1977). Nomenclature follows that of Dickinson (1974).

nontrochacean Pseudophoridae by Knight *et al.* (1960). Hickman and McLean (1990, p. 32) accepted a Permian origination for the Trochacea with the proviso that "we do not consider an early Paleozoic (Middle Ordovician) origin to be out of the question."

A rich record of Cretaceous trochacean occurrence exists in the paleontological literature. Hundreds of species have been described with representatives present from virtually all areas of Cretaceous outcrop, but, expectably, the largest numbers come from the better studied regions of Europe. Despite such coverage in the literature, there has been little effort to bring these disparate records into a coherent pattern reflecting the evolutionary or paleozoogeographic changes within the group during the period. Part of the problem lies in the fact that a great number of the species were described during the preceding century at a time when it was fashionable to assign such forms to extant genera. Thus, there is an overwhelming array of species assigned to such genera as *Trochus, Turbo,* and *Delphinula.* When these records are assembled under the assignments given by the authors, the spectrum of morphologic diversity encompassed by the species assigned to a given genus is so wide as to have little meaning. Subsequent authors have restudied some of these species and reassigned them or otherwise amplified the usual original short descriptions. In many instances, however, the state of preservation of the original material and the quality of descriptions and figures of these species probably preclude the hope that many will ever be satisfactorily assigned.

The problems outlined above are compounded by the changing neontological views of the composition and taxonomic arrangement of the Trochacea. Obviously, much work involving reinvestigation of the already described species needs to be done before a comprehensive picture of the Cretaceous Trochacea can be developed. Even with such effort, many of the questions of assignment will not be resolved because of lack of preservation of critical features, such as complete aperture, radulae, opercula, and soft parts that distinguish certain groups. Despite such seemingly insurmountable obstacles, some variably viable observations can be made. The following discussion should not be viewed as an exhaustive compilation of Cretaceous trochaceans. It is neither exhaustive nor definitive, but is derived from lists compiled over the years from the literature. The information has not been critically analyzed, but it is hoped that it may benefit future investigators in solving the many taxonomic and phylogenetic problems presented by the fossil record of the trochaceans. The notes are arranged according to the families, subfamilies, and tribes recognized by Hickman and McLean (1990), the classification followed in this work.

Family TURBINIDAE Rafinesque, 1815

Subfamily LIOTIINAE Adams and Adams, 1854

Verifiable liotiines are rare in Cretaceous deposits. The most notable exceptions are the species assigned to *Pseudoliotina* Cossmann, 1925, that are discussed below in the "Systematic Paleontology" section. Kollmann (1982) introduced the genus *Eoliotina* for two Albian species from Austria, the type *E. austriaca* Kollmann, 1982, and *Nododelphinula turbinata* Wolff, 1970. Both species have thickened apertures, especially the latter, but the inclination of the aperture is high relative to that of most liotiines.

One Antillean species assigned to *Arene* is described below. A few other Cretaceous species have been assigned to *Arene,* but they lack sufficient preserved features to form a solid basis for placement.

Subfamily ANGARIINAE Thiele, 1924

The inclusion of the Nododelphinulidae Cox, 1960, within the Angariinae by Hickman and McLean (1990) greatly expands the Cretaceous representation of the subfamily. Diverse species have been assigned to the genus *Delphinula* (=*Angaria*), and Cossmann (1916a) listed 11 as validly assigned. Many of these and others so assigned have been subsequently reassigned. The species (*D. acuta, aculeata, muricata,* and *radiata*) described by Zekeli (1852) from the Upper Cretaceous Gosau Beds of Austria are all low-spired forms that tend to develop a spinose, peripheral angulation. The apertural characters are poorly known for all, and their generic assignment is in doubt. Reevaluation is also needed for *D. rotula* Parona, 1909, from the Cenomanian of Italy, *D. scalaris* and *tuberculatus* Guerranger, 1867, from the Cenomanian of France, and *Angaria (A.) gwynae* Allison, 1955, from the Albian(?) of Baja California, Mexico. *Delphinula annularis* Stoliczka, 1868, was selected to serve as the type of the genus *Hanaispira* Kase, 1984. Kase (1984, p. 99, 102) also included within *Hanaispira* other previously described Aptian through Turonian species that had been assigned to *Nododelphinula* and *Fossarus*.

The genus *Nododelphinula* Cossmann, 1916[a], is probably the best represented of the angariines in the Cretaceous. The following species have characters suggestive of the genus:

Turbo acuminatus Deshayes, 1842 in Leymerie (1842), Valanginian, France (doubtful, a possible eucycline in the family Trochidae);
Turbo criveli and *T. crucianus* Pictet and Campiche, 1861, Barremian, Switzerland;
Turbo faucignyanus Pictet and Roux, 1853, Albian, Switzerland;
Turbo? *gouldi* Stanton, 1947, Albian, Kansas;
Turbo guerangeri d'Orbigny, 1842, Cenomanian, France;
Nododelphinula hiraigensis Kase, 1984, Aptian, Japan;
Turbo inaequilineatus Pictet and Campiche, 1861, Aptian, Switzerland;
Turbo mojsisovicsi Favre, 1869, Senonian, Ukraine;
Nododelphinula? *nudula* Sohl, n. sp., Maastrichtian, Puerto Rico;
Calliomphalus pellati Cossmann, 1907, Barremian, France;
Delphinula porteri Blanckenhorn, 1890, Senonian, Lebanon;
Solariella serrata Stanton, 1947, Albian, Texas;
Turbo thurmanni Pictet and Campiche, 1861, Aptian, Switzerland;
Turbo triboleti Pictet and Campiche, 1861, Albian, Switzerland;
Turbo valfinensis étallon, 1859 (see Sayn, 1932), Barremian, France;
Delphinula zittlei Quass, 1902, Maastrichtian, Egypt; and
Nododelphinula sp. Kollmann, 1982, Albian, Austria.

Nododelphinula bellisculptata Jaworski, 1936, from the Albian(?) of Colombia, is possibly a *Metriomphalus*, and that genus is herein assigned to the Colloniinae. *Nododelphinula trechmanni* Sohl, n. sp., from the Maastrichtian of Jamaica, is described in this report. Assignment of other possible Cretaceous angariines must await future evaluation.

Subfamily COLLONIINAE Cossmann, 1916[a]

If the transfer, proposed below, of *Metriomphalus* Cossmann, 1916[a], from the Angariinae to the Colloniinae is accepted, then the range of the subfamily Colloniinae is extended back into the Jurassic. *Petropoma peruanum* Gabb, 1877, possesses a colloniine operculum, but no associated opercula are known for the other Cretaceous species assigned by Cossmann (1918) to the genus. Cossmann (1918, p. 132) assigned five Cretaceous species to *Boutillieria* Cossmann, 1888, with various levels of confidence, but opercular characters are unknown for all. The assignment of *Antillocollonia* is discussed below in the section on "Systematic Paleontology." Shells of *Metriomphalus* with associated opercula are described herein, from the Antillean Cretaceous deposits, and by Delpey (1938), from the Albian and Cenomanian of France. Other *Metriomphalus*-like shells that lack associated opercula are common to almost all Cretaceous levels, and their occurrence is discussed in the section on "Systematic Paleontology" that follows. Further evidence for the presence of members of the subfamily in Cretaceous rocks is provided by disassociated opercula. In addition to the Caribbean opercula reported below in the section "Opercula of Colloniinae," other occurrences have been reported by Parona (1909), from the Cenomanian of Italy, by Gueranger (1867), from the Cenomanian of France, by Fortau (1904), from the Campanian of Egypt, and by Greco (1916), from the Maastrichtian of Egypt.

Subfamily TURBININAE Rafinesque, 1815

Many Cretaceous shells have been assigned as species of *Turbo* Linné, 1758. The name *Turbo* has been applied with uncommon lack of discrimination by authors, and, without access to the original materials, resolution of the problem of assignment of this host of species is far beyond the scope of this contribution. Assignment of Cretaceous species to other turbinid genera has been sparse, and most of these records are in need of reappraisal. Few species have been assigned to *Astraea* Röding, 1798, but among them are the following:

A. bellavistaensis Delpey, 1942, Turonian, France;
A. guerini Bataller, 1945, Santonian of Spain; and
A. kumasoana Matsumoto, 1938, Cenomanian, Japan (assigned to *Paraturbo* by Hayami and Kase, 1977). *Delphinula chouberti* Collignon, 1972, from the lower Albian of Morocco, may be an *Astraea*. The following have been assigned to *Astralium* Link, 1807:
A. bornhardti Müller, 1898, Senonian, Germany;
A. carnaticum Stoliczka, 1868, Cenomanian, southern India;
A. densipocatum Pethö, 1906, Maastrichtian, former Yugoslavia; and
A. fimbriatum, *A. magnum*, and *A. provinciale* Repelin, 1906, Campanian, France.

Cretaceous species described as *Bolma* Risso, 1826, are *B. acicularis* and *B. arnaudi* Delpey, 1942, from the Turonian and Santonian, France. In addition, *Coelobolma* was proposed by Cossmann (1918) for the French Santonian species *C. corbarica*. *Guildfordia* J.E. Gray, 1850 *in* M.E. Gray (1850), is possibly represented by a poorly preserved form, retaining elongate spines on the basal periphery, that was assigned to *G. acantochila* by Müller, 1898, from the Senonian of Germany.

Subfamily PHASIANELLINAE Swainson, 1840

Pictet and Campiche (1861–64, p. 462) listed 14 Cretaceous species assigned to *Phasianella.* Stoliczka (1868, p. 353) accepted 20 species as present in the Cretaceous. Subsequently, these records were discounted by Cossmann (1918), who believed they were mainly pseudomelaniids and that phasianellids had only a Tertiary fossil record. Keen and Robertson (in Knight *et al.,* 1960, p. I274–I275) and Hickman and McLean (1990) have continued the view of an early Tertiary origin for the group.

Family TROCHIDAE Rafinesque, 1815

Subfamily EUCYCLINAE Koken, 1897

Eucycline species have been well represented in the fossil record since the Triassic. As viewed by Hickman and McLean (1990), the subfamily includes not only the Eucyclidae, but the Cirridae and Amberleyidae of various previous classifications. The Tribe Eucyclini is restricted to the Mesozoic and seems to have been most diverse during the Jurassic. Representatives are present at most Cretaceous levels, but are more common in the lower and middle parts of the system. Cretaceous species need revision, as many of the species were described initially as *Littorina, Trochus, Turbo,* or other generic assignments. Cossmann (1916a, pp. 55–56) listed 26 Cretaceous species as members of *Eucyclus. Eucyclus cossmanni* Vidal, 1921, from the Santonian of Spain, and *Amberleya (Eucyclus) japonica* Kase, *in* Kase and Maeda, 1980, from the Barremian of Japan, may be added to the list, but otherwise the name has not been extensively used in the Cretaceous literature.

Until McLean (1984) found living representatives of *Agathodonta* Cossmann, 1918, and McLean (1982) and Hickman and McLean (1990) reinterpreted the Chilodontini, most authors had considered the tribe to be restricted to the Mesozoic. Cretaceous generic diversity is not great, but genera such as *Chilodonta* Étallon, 1862, achieved virtual circum-Tethyan distribution during the period (Sohl, 1987). *Chilodonta* and its record are discussed below in the section on "Systematic Paleontology." *Agathodonta* is represented by three fossil species, all from the Lower Cretaceous of France and Switzerland, that were cited by Cossmann (1918, p. 201) and by *A. brooksi* Allison, 1955, from the Albian to Cenomanian of Baja California. Ryckholt (1862) published a list of 35 Cretaceous species assigned to *Craspedotus* Philippi, 1847, a synonym of *Danilia* Brusina, 1865. Stoliczka (1868, p. 363) cast doubt on some of these assignments, and Cossmann (1918) discounted all Mesozoic records of *Danilia.* Beu and Climo (1974), in their review of the genus, cited Ryckholt's work but discussed only Tertiary records. Hickman and McLean (1990) cited Ryckholt and accepted a Lower Cretaceous to Holocene range for *Danilia* without further discussion.

As currently understood, only a few genera of Cretaceous occurrence are assignable to the tribe Calliotropini Hickman and McLean, 1990. As indicated below, in the section on "Systematic Paleontology," the Cretaceous species assigned to *Calliomphalus* Cossmann, 1888, need reevaluation, and many may be better placed in the Solariellinae. These species, along with those assigned to *Planolateralus* Sohl, 1960, share some common distributional features that are, in some respects, parallel to those noted by Hickman and McLean (1990, p. 80) for living members of the tribe. As indicated by Sohl (1971), these species are common to the Cretaceous sandy-clay, shelfal deposits from North America and northern Europe eastward to the Russian Platform. Like calliotropines in general, they are not common in the warm-water carbonate-platform deposits of the Cretaceous wherein the Chilodontini abound.

Subfamily MARGARITINAE Stoliczka, 1868

A moderate number of Cretaceous species have been described as members of *Margarites* Gray, 1847, or its synonym *Margarita* Leach, 1819. Hickman and McLean (1990) considered the subfamily Margaritinae to have originated in the late Eocene. The Cretaceous species, such as *M. bartonensis* Stanton, 1947, and *M. depressa* Gardner, 1916, all need reassignment.

Subfamily TROCHINAE Rafinesque, 1815

The members of the subfamily Trochinae have a long fossil history ranging back into the Triassic. The number of Cretaceous species described as members of *Trochus* Linné, 1758, is rivaled only by the numbers assigned to *Turbo.* Both names have been used indiscriminately, and, if the Miocene to Holocene range for *Trochus* cited by Hickman and McLean (1990) is accepted, all Cretaceous species need reassignment to other genera. Regardless of this fact, the Trochini are abundantly represented in Cretaceous deposits throughout the world. In Cretaceous carbonate-platform assemblages, species of such genera as *Discotectus* Favre, 1913, and *Tectus* Montfort, 1810, are among the most commonly found gastropods and are individually abundant at many localities as well. The Cretaceous records of both genera are discussed in more detail below, in the section on "Systematic Paleontology." *Clanculus* Montfort, 1810, appears to be represented in the latest Cretaceous by two species, *Turbo retifer* Böhm, 1885, from the Campanian of Germany, and *Clanculus ilerdensis* Vidal, 1921, from the Maastrichtian of Spain.

Among the gibbulines, only a few Cretaceous species have been described as belonging to *Gibbula* Risso, 1826. Among these are *G. jerdoniana* and *G. granulosa* Stoliczka, 1868, from the Campanian of southern India, and *G. bicarinata* Kollmann, 1982, from the Albian of Austria. Stoliczka (1868) listed 20 additional species, from the Aptian through Maastrichtian deposits of Europe, that he considered as members of *Gibbula.*

Other members of the tribe Gibbulini include *Ozodochilus cossmanni* Kase, 1984, which is from the Aptian of Japan and represents the first Cretaceous record of the genus. A few Cretaceous species have been assigned to *Monodonta* Lamarck, 1799. Among them, the main common thread is the presence of an apertural tooth or teeth. Some of them are as follows:

M. allardi Roman and Mazeran, 1920, Turonian, France;
M. antiqua Whitfield, 1891, Aptian, Lebanon (a *Chilodonta*);
M. bartonensis and *M. minuta* Stanton, 1947, Albian, Texas;
M.? *cancellosa* Stephenson, 1941, Maastrichtian, Texas;
M. pacyhyodon Cossmann, 1916[b], Barremian, France; and
M. trochleata Dujardin, 1837, Turonian, France.

Other gibbulines are probably present in the Cretaceous but are attributed to other genera.

The tribe Cantharidini Cotton, 1959, is represented in Cretaceous rocks by only three species of *Jujubinus* Monterosato, 1884: *Tectus junceus* Stoliczka, 1868, Campanian, southern India (*fide* Cossmann, 1918); *J. (J.) roashensis* Abbass, 1963, Cenomanian, Egypt; and *J. botijasensis* Sohl, n. sp., described herein, late Campanian, Puerto Rico.

Subfamily STOMATELLINAE Gray, 1840

Stoliczka (1868, p. 379) listed four Cretaceous species, from the Aptian through the Cenomanian of France, Spain, and Switzerland, that had been previously assigned to *Stomatia* Helbling, 1779. He suggested that, of these species, only *S. bicarinata* Gueranger, 1867, was a true *Stomatia.* I know of no subsequent descriptions of Cretaceous stomatellines.

Subfamily CALLIOSTOMATINAE Thiele, 1924

If, as suggested by Hickman and McLean (1990), Proconulinae of Cox, 1960 (in part), is included within the subfamily Calliostomatinae, its Mesozoic record is considerably extended. Cossmann (1918) included 13 species, mainly from the European Cretaceous, within *Proconulus* in his description and discussion of the genus. Kase (1984) has added *P. hiraigensis,* from the Aptian of Japan, to the list. The following have been described as Cretaceous species of *Calliostoma* Swainson, 1840:

C. amneris Greco, 1916, Maastrichtian, Egypt;
C. bruni Cossmann, 1916[b], Barremian, France;
C. constrictum Whiteaves, 1884, Albian or Cenomanian, British Columbia;
C. cragini Stanton, 1947, Albian, Kansas;
C. decapitatum Wilckens, 1922, Senonian, New Zealand;
C. dievarum Cossmann, 1896, Turonian, France;
C. infracornata Benkö-Czabalay, 1961, Albian, Hungary;
C. kempiana Cooper, 1894, Maastrichtian, California;
C. lignitica Cooper, 1894, Cretaceous, California;
C. massiliense Cossmann, 1903, Coniacian, France;
C. mendizabali Bataller, 1943, Aptian, Spain;
C.? *ojii* Kase, 1980 *in* Kase and Maeda, 1980, Barremian, Japan;
C. radiatum Gabb, 1869, Santonian(?), California;
C. serratum Stanton, 1947, Albian, Texas; and
C. sohli Calzada, 1988, Aptian, Spain.

A few species have been assigned to *Astele* Swainson, 1855: *A. convexa* Kollmann, 1982, Albian, Austria; and *A. sanctivictoris* Calzada, 1988, Aptian, Spain. Kollmann (1982, pp. 19,20) listed four additional species from the Cretaceous of Europe that he considered should be reassigned to *Astele.* The reticulate protoconch, cited as diagnostic of the subfamily by Hickman and McLean (1990), is unknown for any of the above-listed species, and only on the basis of general conchological similarities can any be placed in the subfamily.

Subfamily SOLARIELLINAE Powell, 1951

Cossmann (1918) assigned 13 Cretaceous species, ranging from the Barremian through the Maastrichtian, to *Solariella* Wood, 1842. Hickman and McLean (1990) accepted only a Late Cretaceous origin. A large number of Cretaceous species have the general form, near radial aperture, and noded umbilical margin taken as characteristic of solariellines. These have been described and assigned to *Solariella, Trochus, Solarium,* and other genera but need revision. Such a task is monumental and well beyond the scope of this paper. *Solariella marchmontensis* Sohl, n. sp., from the Maastrichtian of Jamaica, is described herein.

Subfamily UMBONIINAE Adams and Adams, 1854

Hickman and McLean (1990) cited *Trochus grayi* Lees, 1928, from the Cretaceous of Oman, as a possible umboniine. The subgenus *Camitia (Micatia),* from the Maastrichtian of Jamaica, is proposed in the section on "Systematic Paleontology." I know of no other records of the subfamily in Cretaceous rocks, although additional species may be recorded but hidden under other generic assignments.

ANTILLEAN GASTROPOD OCCURRENCE

The trochacean gastropods described in this study may be separated into two groups according to their mode of occurrence. Taxa in the first, and larger, group come from shallow-water deposits associated with rudist pelecypod framework development that was especially widespread in Puerto Rico and Jamaica during the Campanian and Maastrichtian (Kauffman and Sohl, 1974, 1976). These deposits formed during part of the last of the Cretaceous episodes of extensive carbonate-platform deposition in the Antilles (Scott, 1984). Taxa in the second group occur in shelfal shales in association with nonrudist bivalves and a group of gastropods that differs from the rudist framework assemblage.

The first group includes species of such genera as *Discotectus, Tectus, Chilodonta, Metriomphalus,* and *Nododelphinula,* which are common elements of the "corallien" or reef-associated facies of the Jurassic. Along with the patelliform neritid *Pileolus,* fissurellids, actaeonellids, nerineids, and others, these archaeogastropods are among the most common species found in the Cretaceous shallow-water, lagoonal assemblages of the widespread carbonate-platform reefal facies.

Within these lagoonal assemblages, some gastropods, such as the Nerineacea and Actaeonellidae, may be so abundant as to become paucispecific major constituents of rock bodies (Sohl, 1971, fig. 1). The most diverse gastropod assemblages occur in deposits from lagoonal, back-reef environments, and far fewer species occur within the rudist pelecypod framework structures (Kauffman and Sohl, 1974, fig. 27).

Trochacean gastropods in the second group, including *Planolateralus,* are parts of assemblages in shelfal shales. The assemblages contain a smaller proportion of archaeogastropods than do those of the reef-associated facies. Rudist bivalves are generally lacking in these associations, but inoceramid pelecypods may commonly occur. With the exception of the rarity of neogastropods, these assemblages are compositionally reminiscent of the shallow, shelfal Cretaceous molluscan faunas of extra-Tethyan areas. Diversity of trochaceans within these shales is higher than is reported here. The main reason for this disparity is the factor of preservation. Many of the small shells present in these shales are too compressed or otherwise distorted to serve as the basis for description and confident taxonomic placement. More intense collection of these deposits in the future should provide a much better basis for assessing the full character of the trochaceans of the shelfal shale facies.

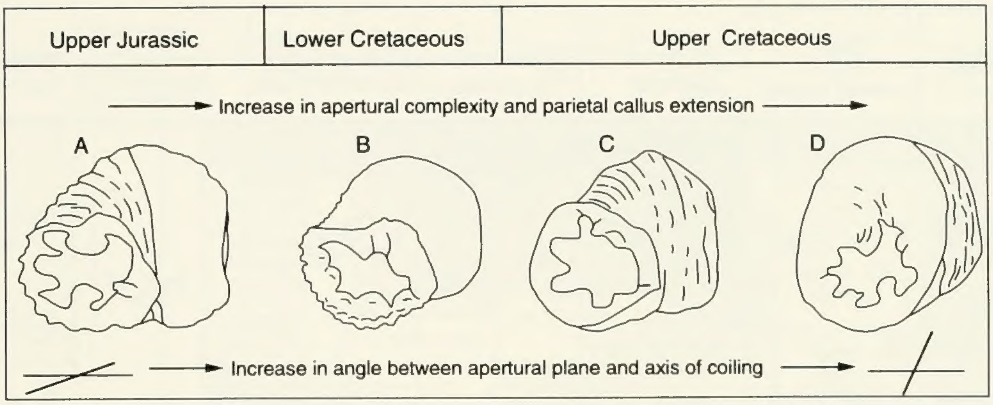
The distinguishing feature of the shale associations is the general lack of those elements common to the lagoonal shales. That is, they lack such genera as *Pileolus* and *Chilodonta* that are so typical of the Jurassic "corallien facies" and the later Cretaceous rudist-framework-associated facies. This fact suggests that the shale-facies trochaceans were derived from different, possibly younger, lineages having greater latitudinal spread and perhaps bathymetric tolerance.

AUTECOLOGY

Not many years ago, the Trochaceans were easily dismissed as browsers and grazers on algae and were considered to be largely confined to harder substrates (Purchon, 1968, p. 45). Subsequent work by many authors, culminating in the excellent summary by Hickman and McLean (1990), has shown that the Trochacea radiated into many habitats and developed feeding modes previously unsuspected among members of the group. Among the Cretaceous species dealt with here, many represent conservative lineages that show little change through their long geologic histories. Others suggest that they may be part of the early radiations into new environments. Some specific morphologic changes within lineages that may be correlated with life habit are dealt with in more detail in the following section.

The shallow-water, lagoonal environments of deposition postulated for many of the Cretaceous units dealt with herein would seemingly provide very suitable substrates for trochacean colonization. The associated abundance of miliolids, larger foraminifers, and dasycladacean and other algae attest to the shallow-water nature of the deposits. Periodic destruction of the rudist frameworks and patch "reefs" provided abundant rubble and bioclastic materials suitable for the firm substrates preferred by many trochaceans. Trochacean gastropods are seldom found within the rudist framework structures but are common in the interbedded units of cobbly limestone and calcareous shale. For example, *Pseudoliotina,* like its modern liotiine analogs, occurs in the limestones of the El Rayo Formation in units containing an abundance of finger-coral debris that may have been derived from the destruction of small patch reefs within the lagoonal facies. Comparison with modern counterparts indicates that the species assigned to *Arene, Nododelphinula, Antillocollonia, Metriomphalus, Chilodonta,* and *Stegnostomella* presumably preferred clinging to hard substrates; they are commonly found in bioclastic deposits, but some may also occur in shales.

There is no primary evidence for the presence of sea grass in Antillean Cretaceous deposits. Brasier (1975) postulated that sea grasses arose in the Late Cretaceous, but, on the basis of the distribution of foraminifers that were common associates of such grasses, he thought they were restricted to European and Asiatic Tethys. Thus, the modern abundance of grass flats in the back-reef lagoonal areas probably had no exact counterpart in the Cretaceous of the Antillean


Upper Jurassic
Lower Cretaceous
Upper Cretaceous
Increase in apertural complexity and parietal callus extension
A
B
C
D
Increase in angle between apertural plane and axis of coiling

Text-figure 4.—Morphologic change among Jurassic and Cretaceous species of *Chilodonta* Étallon, 1862. Diagrammatic text-figures of body whorl of specimens A to D are placed within a relative frame of stratigraphic position and show progressive increase through time of expansion of parietal callus (arrows on top) and of inclination of apertural plane to axis if coiling (angles on bottom of diagram with horizontal line representing axis of coiling. A, *C. clathrata* Étallon, 1862, after de Loriol, 1887, Jurassic (Oxfordian), France; B, *C. cotteaui* Peron, 1900, Neocomian, France; C, *C. marcaisi* (d'Orbigny, 1842), after Roman and Mazeran, 1920, Turonian, France; D, *C. obliqua* n. sp., Maastrichtian, Puerto Rico.

area, but similar environments may have been provided by algal communities. If the Cretaceous trochaceans exhibited tiering, in the sense of small forms living above the substrate on the shafts of vegetation, such niches may have been provided by some forms of algae. Chronic (1952), Peel (1977), Wahlman (1992), and many others have discussed such habitats relative to Paleozoic archaeogastropods, and similar habits may be applicable to such species as *Planolateralus*? *hanoverensis,* which is found exclusively in platform shales. In lagoonal shales, various species of *Discotectus* are especially common. Such shales would not seem to offer a suitable substrate for trochaceans, but the possibility exists that the muds were covered by algal films that bound the soft sediments into a coherent surface. Such binding of sediment would provide not only support, but also a potential food source for the snail. The warm shallow waters of such lagoonal areas would seem well suited for the development of algal mats. In addition, many of the shales contain the remains of dasycladacean green algae. The common co-occurrence of various ceritheacean gastropods in the shales suggests the abundance of algal growth in areas of fine-grained deposition.

TROCHACEAN MORPHOLOGIC TRENDS

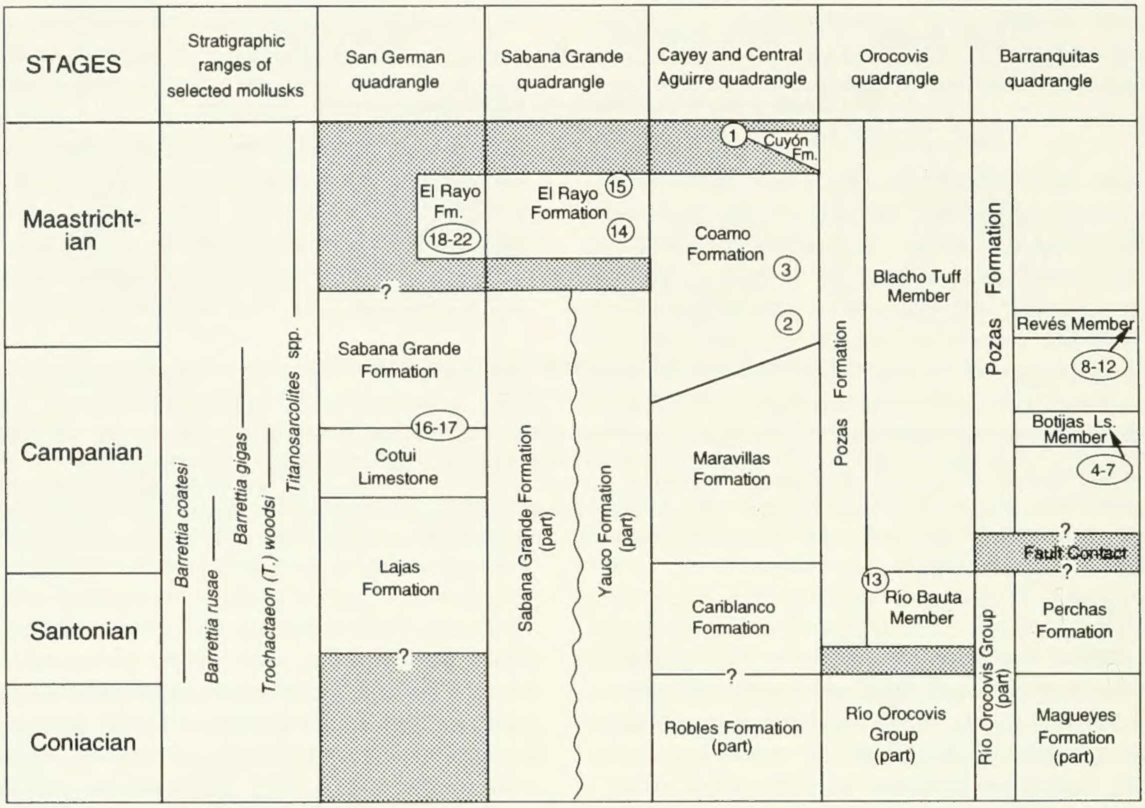
Among the Upper Cretaceous trochacean gastropods found in Puerto Rico and Jamaica, several show morphologies atypical of earlier members of their lineages. In some instances, the appearance of certain characters seems to be indicative of change in life habit for that species, but, for others exhibiting new character sets, no clear-cut functional explanation is obvious.

Chilodonta.—The shells of *Chilodonta* show a constancy in sculpture, with whorls of the spire bearing three to six spiral cords that are crossed by transverse cords of near equal strength, which, in combination, produce a cancellate pattern (Pl. 6, fig. 6). The shell is umbilicate (Pl. 6, figs. 2,3) until maturity, when the opening is covered by apertural callus. The mature aperture is oblique and is interiorly restricted by denticles around the peristome (Pl. 6, figs. 11–17).

Text-figure 4 presents a stratigraphically arranged spectrum of form exhibited by various Jurassic and Cretaceous species of *Chilodonta.* The figure shows what may be interpreted as a number of morphologic changes with time as follows:

1. Increase in complexity of the peristome margin. The type species, *Chilodonta clathrata* Étallon, 1862, from the Jurassic (Oxfordian) of France (specimen A in Text-fig. 4), is typical of the early members of the genus that possessed five denticles of variable size and nearly equally spaced around the peristome margin. Lower Cretaceous species such as *Chilodonta cotteaui* Peron, 1900, from the Neocomian of France (specimen B in Text-fig. 4), show an increase in noding, especially upon the interior of the outer lip, and subdivision of the columellar plication. This trend culminates in *Chilodonta obliqua* n. sp. from the Maastrichtian of Puerto Rico (specimen D in Text-fig. 4). In this species, numerous strong denticles are developed around the peristomal margin, and some show various complexities of subdivision. Additional ridges are developed lateral to the inner lip and extend over the parietal surface.

2. Increase in area of shell base covered by callus. The peristomal margin is thickened on shells of even the earliest species (specimen A in Text-fig. 4), but,



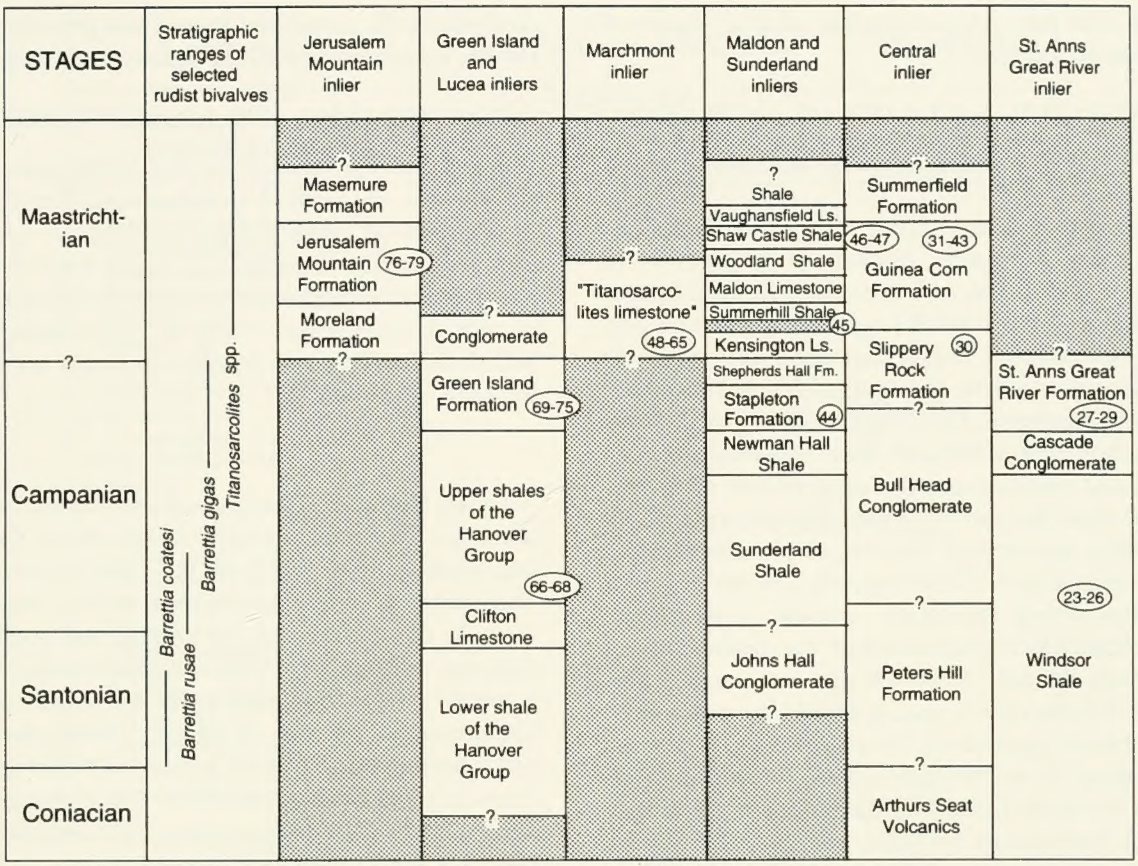
Text-figure 5.—Correlation of the Upper Cretaceous rocks of central and southwestern Puerto Rico. Numbers in circles represent the relative stratigraphic positions of the corresponding numbered localities described in "Stratigraphy and Locality Register." Abbreviations: Fm, Formation; Ls, Limestone. Stratigraphic ranges of mollusks are based primarily on studies by Dommelen (1971) and MacGillavry (1977) and on unpublished observations of my own. Diagram modified from Sohl (1992).

on these, a well-defined callus extends only a short distance onto the parietal surface. In the Cretaceous species (specimens B and C in Text-fig. 4), the outer lip becomes thickened and the callus extends further across the base of the shell, forming a circular surface surrounding the peristome. This trend culminates in the Maastrichtian species *C. obliqua* (specimen D in Text-fig. 4), in which the callus extends over both the parietal surface and the shell base. The margins of the callus lose contact with the shell surface, and the area becomes a callus-covered, flattened disc.

3. Increase in inclination of the apertural plane. Precise measurement of the degree of inclination of the final aperture is lacking for most species. The angle cannot be deduced from growth-line trend on earlier whorls because, during the latest growth stages, the final portion of the body whorl descends. Thus, the final aperture deviates from the angle of the early stages of growth, and available illustrations of most species are insufficient to provide definitive measurements. One can be assured that the angle of apertural inclination of the Jurassic and Lower Cretaceous species (specimens A and B in Text-fig. 4) is not as great as that of the Maastrichtian species (specimen D in Text-fig. 4). The approximate degree of change in this character is represented by angles presented on the bottom of Text-figure 4.

The net effect of the changes outlined above is to produce a limpetlike outline to the shell. The broad, flat, callus-covered shell base, coupled with the proportionally low spire, seems to provide *C. obliqua* with the characters consistent with the ability to cling to hard substrates. This is a habit assumed by several other living members of the Chilodontini (Hickman and McLean, 1990).

Discotectus and Tectus.—The Caribbean Campanian through Maastrichtian record of diversity for *Discotectus* and *Tectus* is unequaled by that of any other area. For the most part, the morphology and sculpture exhibited by the Caribbean species are those basic to earlier members of the genera. Two exceptions to this observation exist and are exemplified by two new genera proposed herein—*Stegnostomella* and *Denticulabrum.* Both are examples of a trend during the Campanian and Maastrichtian for the appearance of new and commonly more complex morphologies among



Text-figure 6.—Correlation of the Upper Cretaceous rocks of central and western Jamaica. Numbers in circles represent the relative stratigraphic positions of the corresponding numbered localities described in "Stratigraphy and Locality Register." Abbreviations: Ls, Limestone; Fm, Formation. Stratigraphic ranges of mollusks are based primarily on studies by Dommelen (1971) and MacGillavry (1977) and on unpublished observations of my own. Stratigraphic nomenclature for the inliers is based on the following: Jerusalem Mountain inlier, Jiang and Robinson (1987); Green Island and Lucea inliers, Sohl (1992); Marchmont inlier, Sohl and Kollmann (1985); Maldon and Sunderland inliers, modified from Chubb (1971); Central inlier, Sohl (1992); St. Anns Great River inlier, modified from Jiang and Robinson (1987).

long-lived, but generally conservative, gastropod stocks present in the Upper Cretaceous assemblages of the Caribbean region.

Denticulabrum is interpreted as a derivative of the *Discotectus* lineage in which, in addition to the plait that lies low on the columella, a spiral ridge is present on the parietal surface, and multiple spiral ridges are present on the interior of the outer and basal lips (Pl. 16, figs. 1,2,4,5). These structures considerably restrict the highly inclined aperture. The functional significance of such elaborate apertural modifications is unclear, and linking them to strengthening of the apertural rim or to deterring predation is speculative.

Stegnostomella, because of the presence of a basal peripheral angulation and concavely flat base, is postulated to have arisen from a *Tectus*-like ancestor. The final aperture is well recessed on the concave base and is surrounded by callus that covers almost the complete shell base (Pl. 18, figs. 6–11). The aperture is margined by two pronounced ridges, one on the parietal surface and the other forming a downturned basal lip. The progressive development of the aperture is shown on figures 5–11 of Plate 18. In essence, the increase in inclination of the final aperture relative to the shell axis converts the shell to a patelliform shape, and one might postulate that the concavely flat, callus-coated base and shape are modifications for a clinging habit. Another analogy may hold equally well. The recessed position of the aperture on the concave base, the confining marginal ridges that are downturned at the edge, and the presence of extended spines at the basal periphery are characters on some shells of the Xenophoridae (Linsley and Yochelson, 1973). In this instance, the spines may have provided a firm support for the suspension of the animal above the substrate for a deposit-feeding mode of life.

These examples indicate that the trochaceans of the Cretaceous Antillean warm-water carbonate-platform facies were a viable group in which even the older and more conservative lineages were still able to experiment with new life styles during the closing phases of the Cretaceous Period.

STRATIGRAPHIC SUMMARY OF ANTILLEAN UPPER CRETACEOUS TRCOCHACEAN OCCURRENCE

The correlation of the Upper Cretaceous lithostratigraphic units containing trochacean gastropods in Puerto Rico and Jamaica is presented in Text-figures 5 and 6. Because they are the most pervasive and perhaps the best studied faunal elements, the rudist bivalves serve as a prime biostratigraphic basis for the correlations presented. The endemic nature of the rudist fauna, however, precludes their utilization for intercontinental correlation. Age assignments are therefore based upon the conventional biostratigraphic tools of ammonite, inoceramid bivalve, or planktonic foraminifer associations. Unfortunately, occurrences of such critical dating fossils are sporadic in the dominantly volcaniclastic sequences of the Cretaceous of the Antillean Islands. Thus, the age assignments presented in Text-figures 5 and 6 should be considered only as tentative appraisals. These age assignments are derived mainly from Pessagno (1976) for foraminifers, Jiang and Robinson (1987) for nannofossils, Kauffman (1976) for inoceramid bivalves, and Sohl (1976) for ammonites and other macrofossils. Additional data on age and correlation of the units are presented in the following section, "Stratigraphy and Locality Register."

Text-figure 7 summarizes the known stratigraphic ranges of the trochacean gastropod species described in this paper. The ranges of many of the species are depicted as short. The assumption that shortness of the given ranges indicates a rapid rate of evolution of the trochaceans in this area must be viewed with caution. In many instances, the range shown on Text-figure 7 is dependent on limited knowledge and may reflect the reconnaissance level of investigation on the paleontology of the Antilles Cretaceous. Some species are known only as a unique occurrence or from very few localities that are at virtually the same stratigraphic level. It is possible, and even likely, that the stratigraphic range for these species will be increased as additional material is found on these or contiguous islands or in Mexico and Central America. In other instances, for example, among the species of *Chilodonta*, there are a sufficient number of occurrences, both geographically and stratigraphically, that we can give credence to their ranges as illustrated.

Precise information on the localities at which the trochaceans discussed here were found is provided in the following section. That section also includes discussions of the associated faunas that provide the basis for the construction of Text-figures 5, 6, and 7.

STRATIGRAPHY AND LOCALITY REGISTER

The following discussions and locality descriptions are keyed to the general locality maps (Text-figs. 1 and 2), the detailed locality maps (Text-figs. 8–14, 16–22), and the correlation charts (Text-figs. 5,6). Text-figure 15 shows facies relations of Upper Cretaceous deposts in central and western Jamaica. U.S. Geological Survey (USGS) Mesozoic locality numbers are provided for each collection.

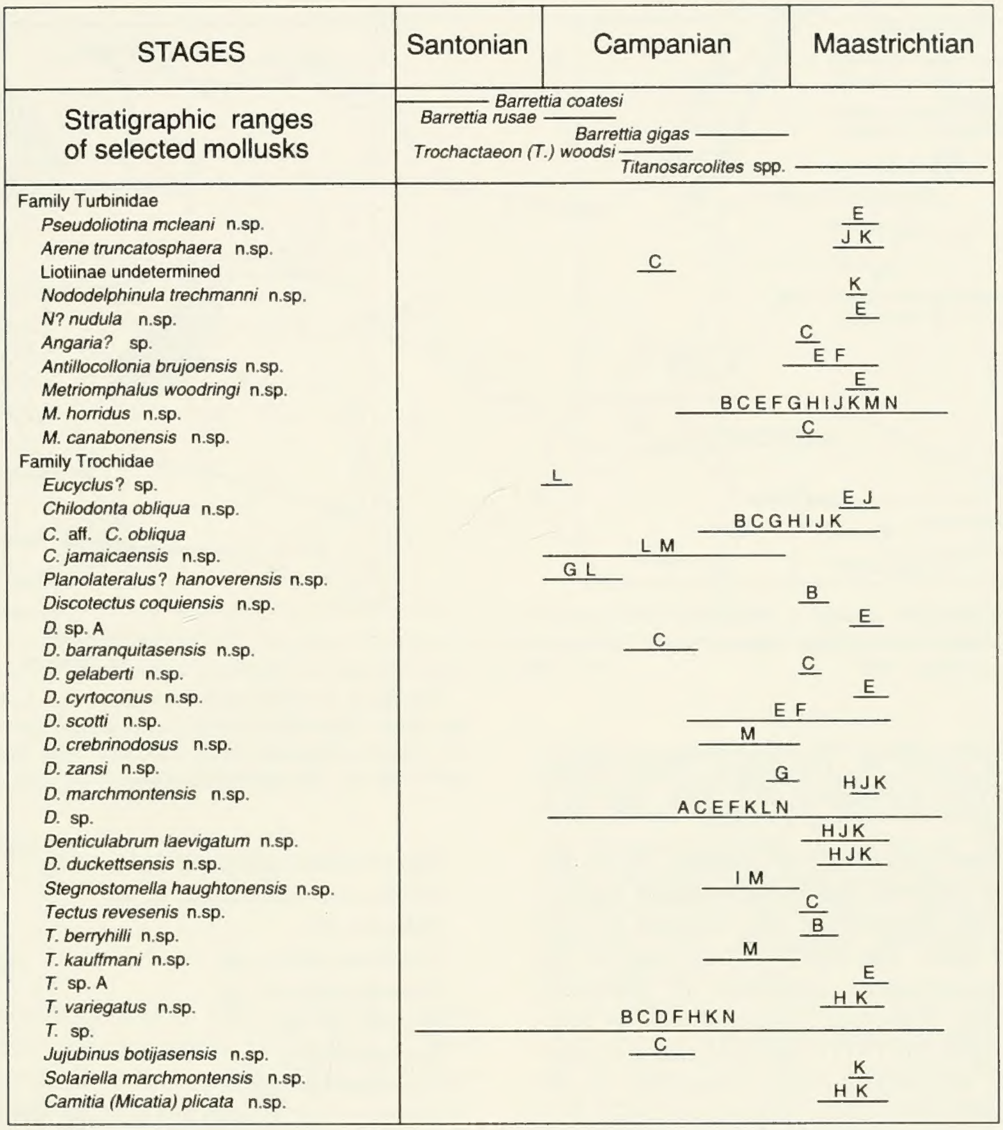
Puerto Rico

Upper Cretaceous trochacean gastropods have been found in two main areas of Puerto Rico, the central and south-central area and the southwestern region. The reader is directed to Glover (1971) for an overview of the geology of the central and south-central area and to Mattson (1960) and Volckmann (1984) for a similar view of the geology of the southwest. Some reappraisal of the age of various Puerto Rico Cretaceous stratigraphic units is presented below in the discussions of individual localities. These changes are reflected in the differences between the correlation chart presented on Text-figure 5 and that given in Sohl and Kollmann (1985, fig. 17).

Cayey Quadrangle

Locality 1.—Cuyón Formation. Limestone exposed in a roadcut of Puerto Rico Highway 162, 0.7 km northwest of intersection of Highways 162 and 1, Barrio Cuyón, Municipio de Aibonito (Text-fig. 8). Puerto Rico meter grid 173,525 N.; 29,970 E. USGS Mesozoic locality 26825 (collectors: N.F. Sohl and P.A. Gelabert, 1957).

Glover (1971, p. 50) described the 75-m-thick Cuyón Formation as follows: "a heterogeneous formation comprising, from the base upward, (1) reddish-gray volcaniclastic rocks, (2) drab reworked tuff with lenses of conglomerate, and (3) limestone." The formation is areally restricted to the northwestern part of the Cayey quadrangle, and the limestone unit is poorly exposed but contains a middle to late Maastrichtian planktonic foraminifer assemblage (Glover, 1971). Although much recrystallized, the limestone contains a macrofossil assemblage, most of which can be determined only to a questionable generic level. Rudist bivalves are common and include *Sauvagesia* sp., *Plagioptychus*? sp., *Antillocaprina*? sp., and indeterminate radiolitids. Nerineid and cerithiid gastropods have been recognized in addition to the trochaceans reported on here.



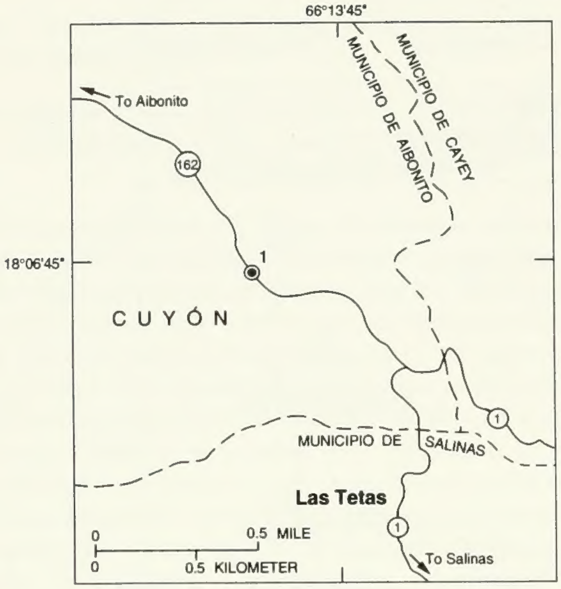
Text-figure 7.—Stratigraphic ranges of the described trochacean species from Puerto Rico and Jamaica. Letters above the stratigraphic range line represent geographic occurrence in Puerto Rican quadrangles A–F and Jamaican inliers G–N as follows: A, Cayey quadrangle; B, Central Aguirre quadrangle; C, Barranquitas quadrangle; D, Orocovis quadrangle; E, Sabana Grande quadrangle; F, San German quadrangle; G, St. Anns Great River inlier; H, Central inlier; I, Sunderland inlier; J, Maldon inlier; K, Marchmont inlier; L, Lucea inlier; M, Green Island inlier; N, Jerusalem Mountain inlier. Stratigraphic ranges of mollusks are based primarily on studies by Dommelen (1971) and MacGillavry (1977) and on unpublished observations of my own.

Central Aguirre Quadrangle

Localities 2 and 3 represent the only known occurrences of Cretaceous rocks within the Central Aguirre quadrangle.

Locality 2.—Coamo Formation. Shale exposures in gullies above abandoned quarry about 10 to 14 m above road level at southeastern end of elliptical hill (Text-fig. 9) 0.88 km north-northwest of intersection of Puerto Rico Route 3 and the Coquí-to-Central Aguirre road (Puerto Rico Route 705), Barrio Aguirre, Municipio de Salinas. Area of 200 m2 centered at Puerto Rico meter grid 16,200 N.; 173,300 E. USGS Mesozoic localities 26393 (collector: H.L. Berryhill, Jr., 1956), 26829 (collectors: N.F. Sohl and P.A. Gelabert, 1957), and 30358 (collectors: N.F. Sohl and W.O. Ross, 1973).

Locality 3.—Coamo Formation. From a 3-m-thick cobbly shale unit interbedded with massive limestone on crest of elliptical hill (Text-fig. 9) 1.45 km north-northwest of intersection of Puerto Rico Route 3 and the Coquí-to-Central Aguirre road (Puerto Rico Route 705), Barrio Aguirre, Municipio de Salinas. Puerto



Text-figure 8.—Collection locality 1, Municipio de Aibonito, Puerto Rico. Base from U.S. Geological Survey Cayey 7.5-minute quadrangle, scale 1:20,000, 1960.

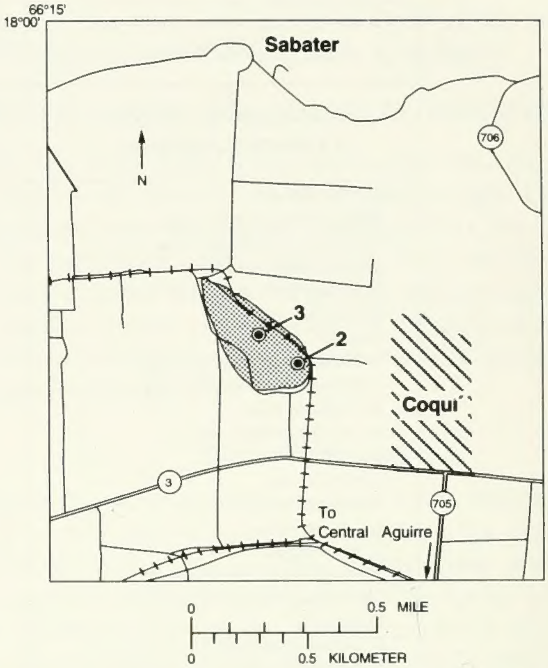
Rico meter grid 16,410 N.; 173,100 E. USGS Mesozoic locality 30541 (collectors: N.F. Sohl and H.A. Kollmann, 1974).

Localities 2 and 3 occur on an isolated, 70- to 80-m-high hill that projects above surrounding Quaternary alluvial plain deposits on the southern Coastal Plain of Puerto Rico. The southwestern slope of the hill provides discontinuous exposures of massively bedded Cretaceous limestone. Artificial cuts by bulldozed tracks (visible in 1973) indicated that the intervening intervals are predominantly composed of cobbly limestone, tuffaceous sands, and less resistant shale units. The limestones of the lower one-half of the hill contain an abundance of corals. Cross sections of coral heads nearly 1 m in diameter have been noted. In the less resistant cobbly limestone units, *Acropora*-like finger corals are especially abundant, but rudist bivalves are rare. Of special note is the occurrence of one specimen of *Barrettia gigas.*

At the southeastern end of the hill, a small abandoned quarry exposes limestone at the base; gullies about 10 m above the limestone provide a 4-m-thick section of much sheared, brown, tuffaceous shale (locality 2). This shale sequence yields a moderately diverse, but largely undescribed, lagoonal assemblage of mollusks as follows:

Gastropoda:

Emarginula pojetai Sohl, 1992
Metriomphalus horridus Sohl, n. sp.
Chilodonta aff. *C. obliqua* Sohl, n. sp.

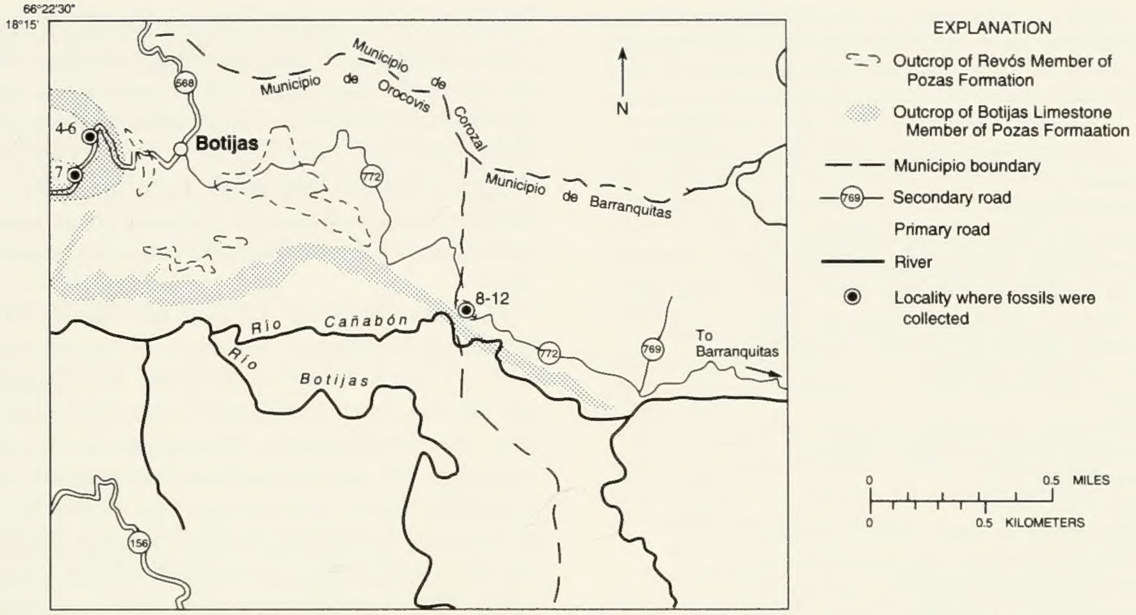


Text-figure 9.—Collection localities 2 and 3, Municipio de Salinas, Puerto Rico. Base from U.S. Geological Survey Central Aguirre 7.5-minute quadrangle, scale 1:20,000, 1960. Patterned area represents elliptical hill mentioned in text.

Discotectus coquiensis Sohl, n. sp.
Tectus berryhilli Sohl, n. sp.
Pileolus sp.
Trochonerita n. sp.
Pseudomalaxis? sp.
Pyrazus n. sp.
Cerithiopsis n. sp.
Turritella n. spp.
Laxispira cf. *L. monilifera* Sohl, 1964
Helicaulax n. sp.
Strombidae n. gen. and n. sp.
Globularia n. sp.
Ampullospira n. sp.
Tuba sp.
Fusinid indet.
Mitrid undet.
Ancillus (Ancillus) n. sp.
Amuletum? sp.
Nerineids undet.
Actaeonella coquiensis Sohl and Kollmann, 1985
Acteon? sp.
Cylichna sp.
Ringicula (Ringicula) n. sp.

Pelecypoda:

Pseudocucullaea cf. *P. gregoryi* Olsson, 1944
Pteria sp.
Crenella sp.



Text-figure 10.—Collection localities 4–7, Municipio de Orocovis, and localities 8–12, Municipio de Barranquitas, Puerto Rico. Base from U.S. Geological Survey Barranquitas 7.5-minute quadrangle, scale 1:20,000, 1957.

Lima sp.
Neithea bexarensis Stephenson, 1941
Ostrea sp.
Granocardium sp.
Parmicorbula sp.

Scaphopoda:

Dentalium sp.

The limestones and cobbly shales from the upper part of the hill, including those of locality 3, bear abundant rudist bivalves that include *Titanosarcolites giganteus* (Whitfield), 1897, *Plagioptychus jamaicensis* (Whitfield), 1897, *Durania nicholasi* (Whitfield), 1897, and *Parastoma guitarti* (Palmer), 1933. Thus, *Tectus berryhilli* Sohl, n. sp., described herein from locality 2, may be assigned to the Maastrichtian range zone of *Titanosarcolites.*

Barranquitas Quadrangle

Fossiliferous Upper Cretaceous limestones and calcareous shales crop out in the northwestern quadrant of the Barranquitas quadrangle (Text-fig. 10). These fossiliferous units were mapped by Briggs and Gelabert (1962) as the Botijas Limestone Member and Revés Member of the Coamo Formation. Subsequently, Briggs (1969) revised the stratigraphic nomenclature of this area and included these members within Berryhill's (1965) Pozas Formation. As is indicated below, under the discussions of the collection localities, some of the original mapping of these fossiliferous members may need revision because paleontological evidence suggests that three units may be present rather than two and that the Botijas Limestone Member is more likely Campanian than Maastrichtian (Text-fig. 5). This reassessment of the age of the Botijas Limestone Member is based upon the presence, at some localities, of the gastropod *Trochactaeon* (*T.*) *woodsi* (Rennie), 1930. Elsewhere, this species occurs in upper Campanian units.

Localities 4, 5, and 6.—Botijas Limestone Member of the Pozas Formation. Roadcuts and hill slope above and south of Puerto Rico Route 568 between Orocovis and Botijas at the small settlement along the sharp road bend 0.56 km (airline) a little north of west from Botijas, Barrio Botijas, Municipio de Orocovis (Text-fig. 10). Vicinity of Puerto Rico meter grid 45,550 N.; 158,880 E. Locality 4, USGS Mesozoic localities 26802 (collectors: N.F. Sohl and P.A. Gelabert, 1957) and 33365 (collectors: N.F. Sohl and W.O. Ross, 1973). Locality 5, USGS Mesozoic locality 31489 (collectors: N.F. Sohl and W.O. Ross, 1965). Locality 6, USGS Mesozoic locality 29392 (collectors: N.F. Sohl and W.O. Ross, 1965). Stratigraphic positions of localities 4–6 are indicated in Table 1. These exposures are in the type area of the Botijas Limestone Member designated by Briggs and Gelabert (1962) and serve well as a reference section.

The section is terminated at the base of unit 1 by a fault contact; farther south along the road, another section begins that repeats part of the previous section in ascending order. Above the rudist framework bed of unit 6 of the measured section and higher on the hill,

Table 1.—Section of the Botijas Limestone Member of the Pozas Formation beginning on bench of hill slope above and extending below into roadcut of Puerto Rico Route 568 at localities 4, 5, and 6.

	Thickness (meters)
Pozas Formation:	
Botijas Limestone Member:	
9. Limestone, gray, consisting of a framework of closely spaced, elongate, tubular specimens of *Barrettia* sp. B Dommelen, 1971	1 to 1.3
8. Sand, muddy, calcarenitic, containing large specimens of *Durania nicholasi* (Whitfield), 1897, in growth position	0.5
7. Covered	2.0
6. Limestone, gray, calcarenitic, containing common worn clasts (to 3 cm) of radiolitid rudists	1.0
5. Covered	4.0
4. Limestone rubble in shaly matrix; limestone cobbles are blue gray and crystalline and contain abundant bioclasts. One meter above base is a 1.2-m-thick zone of large fragments of *Durania nicholasi* (Whitfield), 1897. Shales between clasts contain such epifaunal bivalves as *Brachidontes, Ostrea,* and *Spondylus* and very small terebratuloid brachiopods. *Spondylus* and *Ostrea* are common encrusters on limestone clasts (locality 6, USGS Mesozoic locality 29392)	3.5
3. Limestone, blue-gray, crystalline, massive, grading upward into massive calcarenitic limestone, which contains occasional larger clasts of *Durania.* Exposure discontinuous	17.0
2. Limestone, silty, blue-gray when fresh, but locally decalcified and brown; limestone is thin to medium bedded near base and grades to massive at top; nodular zones are present throughout. Whole and fragmentary rudists (radiolitids, *Plagiotychus,* and *Barrettia*) become more common upward in unit, and some, possibly derived, limestone blocks containing abundant *Acropora*-like corals occur near top of unit (locality 4, USGS Mesozoic localities 26802 and 33365 in upper part of unit; locality 5, USGS Mesozoic locality 31489, in lower part of unit)	8.0
1. Limestone, dark-blue-gray, silty, containing stromatoporoids, grading up to brownish, tuffaceous, mainly decalcified limestone	2.2
Total Botijas Limestone Member	39.2 to 39.5

additional exposures are present. Following a covered interval above the measured section is an interval of brownish silty limestone or calcareous siltstone that is overlain by a cliff-forming, poorly fossiliferous, silty to calcarenitic limestone. The whole section is capped by massive, bedded, tuffaceous sandstone. The upper part of this sequence appears to be at least 80 m thick.

Locality 7.—Botijas Limestone Member of the Pozas Formation. Roadcut of Puerto Rico Route 568 between Orocovis and Botijas, and about 0.6 km (airline) west-southwest of Botijas, Barrio Botijas, Municipio de Orocovis (Text-fig. 10). Puerto Rico meter grid 45,300 N.; 158,800 E. USGS Mesozoic locality 29394 (collectors: N.F. Sohl and W.O. Ross, 1965).

This collection was made from limestones exposed discontinuously along the highway in an interval that corresponds to unit 4 of the measured section given above.

Localities 8, 9, 10, 11, and 12.—Revés Member of the Pozas Formation. Roadcuts of Puerto Rico Route 772, on north valley wall of the Río Cañabón, 1.85 km (airline) east-southeast of road intersection in Botijas, Barrio Cañabón, Municipio de Barranquitas (Text-fig. 10), almost on boundary with Municipio de Orocovis. Puerto Rico meter grid 44,490 N.; 161,090 E. Locality 8, USGS Mesozoic locality 28829 (collector: N.F. Sohl, 1963). Locality 9, USGS Mesozoic locality 30387 (collectors: N.F. Sohl and W.O. Ross, 1973). Locality 10, USGS Mesozoic locality 30388 (collectors: N.F. Sohl and W.O. Ross, 1973). Locality 11, USGS Mesozoic localities 29365 (collectors: N.F. Sohl and W.O. Ross, 1965) and 30389 (collectors: N.F. Sohl and W.O. Ross, 1973). Locality 12, USGS Mesozoic locality 33364 (collectors: N.F. Sohl and W.O. Ross, 1973). Stratigraphic positions of localities 8–12 are indicated in Table 2.

Briggs and Gelabert (1962) mapped the lower limestone unit of the section given above as a continuation of the Botijas Limestone Member eastward from the type area (localities 4–7 on Text-figure 10). The faunas of the limestones of these two areas differ sufficiently to question their exact contemporaneity. For example, the common presence of large specimens of *Trochactaeon (T.) woodsi* (Rennie) in units 2–6 of the above section is in distinct contrast to its total absence from localities 4–7. Further field work is needed to demonstrate whether these differences are stratigraphic or environmentally related.

Orocovis Quadrangle

Locality 13.—Río Bauta Member of the Pozas Formation. Trail along north- to northeast-trending ridge crest above Puerto Rico Route 157 and about 0.3 km slightly east of north of bridge crossing of Río Bauta, Barrio Damian Arriba, Municipio de Orocovis (Text-fig. 11). Puerto Rico meter grid 44,850 to 44,900 N.; 150,250 E. USGS Mesozoic locality 28836 (collector: N.F. Sohl, 1963).

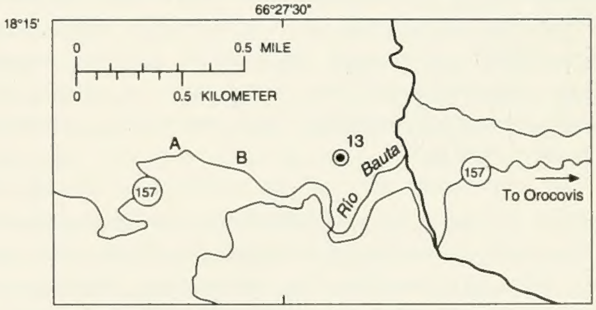
This collection comes from the upper part of the Río Bauta Member of the Pozas Formation (Text-fig. 5). As defined by Briggs (1969), the member consists of about 100 m of dark-colored, calcareous, volcanic

Table 2.—Section of the Botijas Limestone and Revés Members of the Pozas Formation at localities 8 through 12. [Measured from streambed of the Río Cañabón (Puerto Rico meter grid 44,300 N.; 161,000 E.) northward to the roadcuts of Puerto Rico Route 772 (Puerto Rico meter grid 44,490 N.; 161,090 E). Housing development along the highway encroached upon and eradicated the uppermost part of the section by 1973; detailed measurements were first made in 1965. The exact position of locality 8, USGS Mesozoic locality 28829, within the section could not be determined by G.L. Wingard; however, N.F. Sohl's field notes and sketches indicate that it most likely falls in unit 13.]

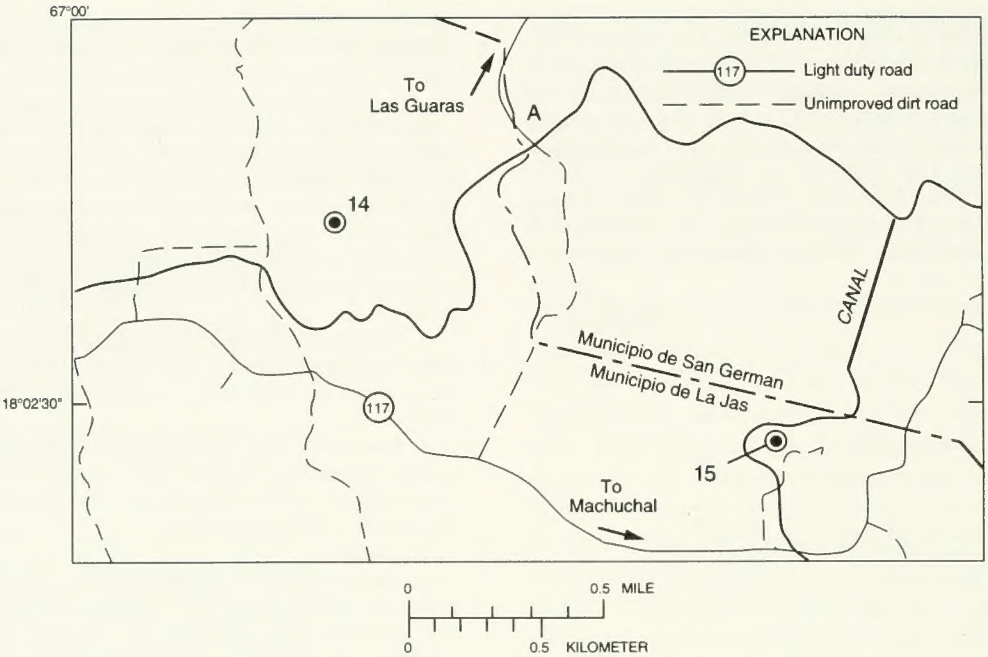
	Thickness (meters)
Pozas Formation:	
Revés Member:	
15. Silt, beige to brown, tuffaceous, cobbly; bedding medium below, grading upward to massive	8.0
14. Limestone, gray to blue-gray, silty, massively bedded, sparsely fossiliferous, containing a few radiolitid rudist bivalves and stromatoporoids	1.1
13. Limestone, yellow-brown, cobbly, interbedded with shale, abundantly fossiliferous; upper 0.3 m contains a concentration of individual and clustered *Barrettia* (locality 9, USGS Mesozoic locality 30387); below, shale contains a few irregular echinoids and a moderately diverse mollusk assemblage (locality 10, USGS Mesozoic locality 30388)	3.2
12. Shale, reddish near base becoming brown above, containing diverse and abundant nonrudist mollusks (locality 11, USGS Mesozoic localities 29365 and 30389)	2.4
11. Limestone, blue-gray, cobbly to well-bedded, fossiliferous, containing rare radiolitid rudists and internal molds of other mollusks	1.5
10. Limestone, blue-gray, weathering to beige, silty, cobbly, interbedded with beige to grayish shale; shale distorted and squeezed between cobbles, fossiliferous, containing a few rudist bivalves but a varied assemblage of other mollusks (locality 12, USGS Mesozoic locality 33364)	7.0
9. Siltstone, nodular, tuffaceous, well-bedded, interbedded with greenish-gray shales; local zones of conglomerate; fossils sparse	8.0
Total Revés Member	31.2
(Roadcut section terminated by a fault zone at base of unit 9; section continues on valley wall below road level where units dip at a much higher angle. Displacement on fault unknown.)	
Botijas Limestone Member:	
8. Silt and clay, interbedded, brownish to reddish, containing scattered volcanic pebbles	4.0
7. Limestone, reddish to grayish, calcarenitic near top, but, downward, terrigenous components, including volcanic fragments, increase in abundance; massively bedded; fossils mainly fragmentary	6.5
6. Limestone, light-gray, calcarenitic, and massively bedded; fossiliferous, with rudist bivalves as prominent constituents including *Plagioptychus* sp. (clustered in zones), small radiolitids, and rare *Barrettia* sp.; the large gastropod *Trochactaeon* (*Trochactaeon*) *woodsi* (Rennie), 1930, occurs sparsely along with scattered corals and pockets of algal debris	5.0
5. Mainly covered, but with a rubble zone at top where individual specimens and clusters of *Barrettia* sp. and a few *Durania* sp. weather out on hill slopes	6.0
4. Limestone, gray, weathering to a hummocky surface; fossiliferous surface shows weathered-out cross sections of *Plagioptychus* sp., *Trochactaeon* (*T.*) *woodsi*, and other mollusks	0.6
3. Covered	1.2
2. Limestone, gray to reddish-gray, massive (forming bluffs along the Río Cañabón), fossiliferous, containing rare *Barrettia* sp., common large fragments of *Durania* sp., local concentrations of *Plagioptychus* sp., and common *Trochactaeon*	4.5 to 6.0
Total Botijas Limestone Member	27.8 to 29.3
Unnamed member:	
1. Tuff and volcanic conglomerates (exposed in river bed); thickness unknown.	
Total Pozas formation	59.0 to 60.5

sandstones, siltstones, and mudstones with minor adjuncts of limestone, generally as lentils.

The unit was excellently exposed in the middle and late 1960's in a series of cuts along Puerto Rico Route 157 from near Puerto Rico meter grid 45,105 N.; 148,910 E., to 45,000 N.; 149,490 E. (A to B on Text-fig. 11). Most of these roadcuts were obscured by slump or overgrowth by 1973. In this area, immediately overlying coarse, dark-purplish, volcaniclastic



Text-figure 11.—Collection locality 13, Municipio de Orocovis, Puerto Rico. Base from U.S. Geological Survey Orocovis 7.5-minute quadrangle, scale 1:20,000, 1957. Cuts between sites A and B provided good exposures in the 1960's of the Río Bauta Member of the Pozas Formation, as discussed in text.



Text-figure 12.—Collection localities 14 and 15, Municipio de Lajas, Puerto Rico. Base from U.S. Geological Survey Sabana Grande 7.5-minute quadrangle, scale 1:20,000, 1966. Silicified limestones similar to those at locality 14 are exposed at site A, as discussed in text.

conglomerate, the lower part of the Río Bauta Member is mainly brownish tuffaceous siltstone and shale. About 4 m above the base, numerous echinoids and the gastropod *Trochactaeon* cf. *T. (T.) woodsi* (Rennie), of Sohl and Kollmann (1985) was found. Higher in the section, at about 15 m above the base, a 0.5-m-thick bed of rubbly limestone yielded the rudist bivalve *Barrettia coatesi* Chubb, 1967, in abundance. This rudist is known to occur in the upper Santonian part of units dated as late Santonian to early Campanian in Jamaica. An overlying unit of tuffaceous silt and sand of undetermined thickness follows and is overlain by a sequence of mainly mudstones. These mudstones appear to have been deposited in very near shore conditions, some in brackish-water environments. Beds containing paucispecific accumulations of cerithiacean (potamidid) gastropods suggesting mudflat assemblages alternate with beds dominated by carditid bivalves and small ostreids. This interval is capped by a welded tuff unit.

The uppermost part of the member is exposed at locality 13 along the cited north- to northeast-trending ridge north of the bridge over the Río Bauta. Here the tuff units are overlain by calcareous, fossiliferous mudstones and intervening limestone beds composed of radiolitid rudist pavements to 1 m thick (USGS Mesozoic locality 28836) and cobbly limestone. Upward the member grades through brownish tuffs containing calcareous nodules into red and greenish volcaniclastic beds of the Blacho Tuff Member of the Pozas Formation.

In sum, the presence of *Barrettia coatesi* and a precursor of *Trochactaeon* (*T.*) *woodsi* in the lower part of the Río Bauta Member suggests a late Santonian assignment for those beds. The beds at locality 13 are slightly higher stratigraphically, but most likely fall within the same age range.

Sabana Grande Quadrangle

Locality 14.—El Rayo Formation. Saddle and gullies below crest of 125-m-high hill east of Quebrada Jicara, 4.75 km south-southwest of Sabana Grande, Barrio Lajas Arriba, Municipio de Lajas (Text-fig. 12). Vicinity of Puerto Rico meter grid 23,900 N.; 93,400 to 93,600 E. USGS Mesozoic localities 28664 (collector: Peter Mattson, 1962), 28748 (collectors: N.F. Sohl and Peter Mattson, 1962), 29075 (collector: N.F. Sohl, 1963), 29088 (collectors: N.F. Sohl and E.G. Kauffman, 1964), and 29361 (collectors: N.F. Sohl and W.O. Ross, 1965).

The collections come from silicified limestones within the El Rayo Formation, exposed below the crest of the hill. Distribution of silicification is erratic and was probably controlled by fractures or fault lines that are not obvious on the local outcrop. Similar silicification is seen in limestones further to the east along the ridge trend, where it is exposed in roadcuts of Puerto Rico Route 328 south of Las Guaras (A on

Text-fig. 12). At that locality, however, siliceous gangue cements the rock so thoroughly that it prevents recovery of good specimens from the acidized residues. By contrast, recovery of complete specimens is common at locality 14.

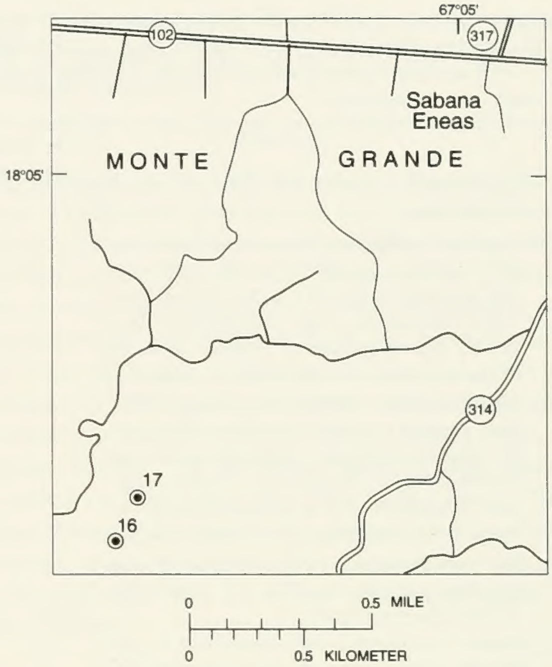
The lower part of the hill at locality 14 shows discontinuous exposures of massive, gray limestone containing common ostreid bivalves and fragments of other mollusks. Float on the hill slopes and in gullies indicates that this limestone is overlain by a poorly exposed interval of presumed interbedded brownish shale and limestone. The blocks of silicified limestone providing the fauna here studied come from this interval, which probably contains several beds of limestone, as indicated by residues recovered from the acidizing.

The top of the hill is capped by first a light-gray limestone containing such rudist bivalves as *Parastroma* sp. and *Titanosarcolites giganteus* (Whitfield), 1897, and an overlying gray, massively bedded, dense limestone containing only scattered fragments of fossils. *Titanosarcolites* does not occur in the silicified residues, but its presence in the limestones immediately above suggests a Maastrichtian assignment for the fauna. In composite, the silicified limestone contains a most varied molluscan fauna, including representative species of nearly 80 gastropod genera, an abundance of pelecypods, including the rudists *Antillocaprina, Plagioptychus, Parastroma, Orbignya, Durania,* and various other smaller radiolitids that occur as individual specimens or small clusters. Corals and coralline algae are also abundant. The lack of representation of framework building suggests deposition in a lagoonal environment. This is the most diverse assemblage of Upper Cretaceous mollusks yet found in the Antilles.

Locality 15.—El Rayo Formation. South of irrigation ditch on slope of 60-m-high hill north of Puerto Rico Route 117, 0.8 km (airline) northeast of Escuela Thomas A. Edison, Barrio Plata, Municipio de Lajas (Text-fig. 12). Puerto Rico meter grid 22,990 N.; 95,210 E. USGS Mesozoic localities 28746 (collectors: N.F. Sohl and Peter Mattson, 1962) and 29360 (collectors: N.F. Sohl and W.O. Ross, 1965).

Brownish to reddish-purple shales are poorly exposed on the lower slope of the hill at locality 15 (Text-fig. 12). One zone, rich in irregular echinoids, is present, but most other fossils are fragmentary and weather out on the slope.

Most common among the fauna recovered at locality 15 are *Titanosarcolites* sp. (fragment), *Durania* sp., *Exogyra* sp., *Spondylus* sp., *Turritella* sp., other small mollusks, corals, and algal clasts. The shales are overlain by impure limestones containing near-coquina zones of *Ostrea arizpensis* Böse, 1913. The oyster limestone has a very high dip and may be the highest Cretaceous unit in the area because flatter lying Tertiary deposits are exposed in close proximity to the south and east. The presence of *Titanosarcolites* suggests a Maastrichtian assignment for the shale. Additionally, similar oyster-rich limestones are seen to the east in Puerto Rico, at the top of the Miramar Formation of the Rio Descalabrado quadrangle (Glover, 1971) and in the oyster limestones of the Santoy and Jerusalem Mountain inliers of western Jamaica. In all these areas, the oyster-rich limestones lie at or near the top of the Cretaceous section.



Text-figure 13.—Collection localities 16 and 17, Municipio de San German, Puerto Rico. Base from U.S. Geological Survey San German 7.5-minute quadrangle, scale 1:20,000, 1966.

San German Quadrangle

Locality 16.—Cotui Limestone. Exposures along trail on ridge crest 2.6 km south-southeast of highway intersection in Monte Grande, Barrio Tuna, Municipio de San German (Text-fig. 13). Puerto Rico meter grid 26,125 N.; 81,980 E. USGS Mesozoic locality 30518 (collectors: N.F. Sohl, R.P. Volckmann, and W.O. Ross, 1974).

This collection comes from the top of the Cotui Limestone in partly silicified limestone that is overlain by volcanic sediments of the Sabana Grande Formation. The limestone contains *Trochactaeon* (*T.*) *woodsi* (Rennie), typical of the Cotui. The unit is underlain by a limestone containing an abundance of nerineid gastropods followed below on the main hill slopes by massively bedded limestone.

Table 3.—Section of El Rayo Formation at localities 18 through 22 (Text-fig. 14). [Measured from irrigation ditch at south flank of quarry northward across east-west-striking beds. Dip near vertical in basal units, lessens upward.]

	Thickness (meters)
El Rayo Formation:	
11. Limestone, light-gray, dense, massive to medium-bedded, fossiliferous with some cobbly limestone and shaly beds in lower part. Upper limestones less fossiliferous than lower; upper limestones contain scattered *Titanosarcolites* sp. and small clusters of *Distafenella* sp.; rubbly limestones in lower part contain common *Titanosarcolites* sp., *Biradiolites cubensis*, stromatoporoids, and colonial corals (locality 18, USGS Mesozoic locality 30368); a thin shale occurs locally at base of unit and is much sheared, but contains a poorly preserved assemblage of small mollusks (locality 19, USGS Mesozoic locality 30367)	31.0
10. Volcanic mudstones, dark-purplish-red, containing some zones of conglomerate; unit thickens to east and thins and pinches between limestone units 8 and 11 at west end of quarry	12.0
9. Shale, sandy, brown, tuffaceous	1.0
8. Limestone, gray, massive near top and cobbly below. Upper part contains scattered radiolitid rudists and common foraminifers; lower rubbly limestone has abundant fossil cobbles; coarse angular bioclasts occur between cobbles. Unit 8 contains *Parastroma* sp., *Barrettia* sp., *Antillocaprina* sp., *Chiapasella* sp., and colonial corals	7.5
7. Shale, brownish-gray, massive with hackly fracture, containing lenticular siltstone beds and concretions, fossiliferous; solitary corals abundant, *Turritella* sp. and other small mollusks scattered (locality 22; USGS Mesozoic locality 30366)	10.7
6. Covered	1.0
5. Limestone, silty, cobbly, weathers brown and contains abundant *Antillocaprina* sp., radiolitid rudists, and corals	0.3
4. Limestone, shaly, weathering brownish, containing abundant small, low, but rapidly spreading form of radiolitid rudists (locality 20; USGS Mesozoic locality 30365)	0.1
3. Limestone, cobbly, shaly; shale contains diverse small mollusk assemblage, corals, dasycladacean alga, and encrusting Bryozoa; cobbles consist of *Antillocaprina* sp., *Plagioptychus* sp., and other small rudists (locality 21; USGS Mesozoic locality 30364)	0.3
2. Limestone, gray, composed mainly of a biostromal accumulation of recumbent *Antillocaprina* n. sp.	1.0
1. Limestone, gray, weathers brown, massively bedded to cobbly, discontinuous exposures, fossiliferous: contains *Chiapasella radiolitiformis* (Trechmann), 1924, and *Barrettia* sp. near base; *Antillocaprina* sp. and *Distafenella* sp. more common above	16.8
Total El Rayo Formation	81.7

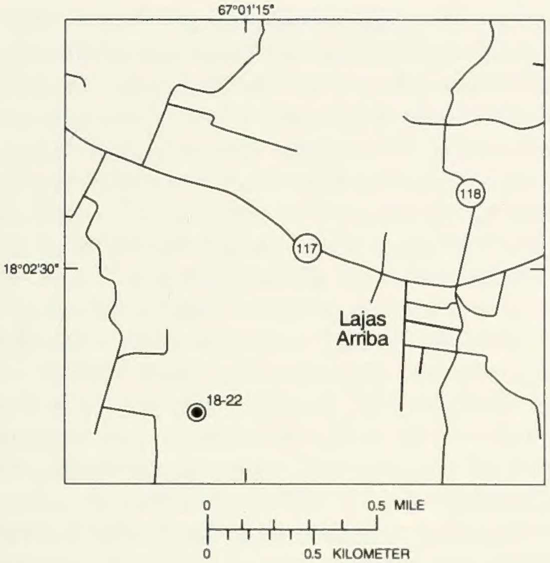
Locality 17.—Sabana Grande Formation. Erratic block of silicified Cotui Limestone incorporated in basal breccia of the Sabana Grande Formation exposed along ridge crest, foot trail about 2.73 km northeast of El Brujo, Barrio Tuna, Municipio de San German (Text-fig. 13). Puerto Rico meter grid 26,300 N.; 82,025 E. USGS Mesozoic locality 30343 (collector: Peter Mattson, 1955).

The assemblages of localities 16 and 17 lie stratigraphically below the first occurrence of *Barrettia gigas,* suggesting an assignment to a middle to lower upper Campanian level. The presence of *Trochactaeon* (*T.*) *woodsi* (Rennie) suggests correlation with units 2–6 of the section given for localities 8–12 of the Barranquitas quadrangle.

Locality 18,19,20,21 and 22.—El Rayo Formation. Quarry north of Parada de Señal Irizarry, about 275 m north of unpaved road that follows Antigua via del Ferrocarril and 1.5 km (airline) west-southwest of junction of Puerto Rico Routes 117 and 118 in Lajas Arriba, Barrio Lajas Arriba, Municipio de Lajas (Text-fig. 14). Puerto Rico meter grid 22,550 N.; 89,750 E. Locality 18, USGS Mesozoic locality 30368. Locality 19, USGS Mesozoic locality 30367. Locality 20, USGS Mesozoic locality 30365. Locality 21, USGS Mesozoic locality 30364. Locality 22, USGS Mesozoic locality 30366. Collectors for localities 18–22: N.F. Sohl and W.O. Ross, 1973. No fossils from localities 19 and 22 are described in this report. Stratigraphic positions of localities 18–22 are indicated in Table 3.

The assemblages present within the limestone of this section lie stratigraphically above those of both the Cotui Limestone at localities 16 and 17 and the overlying beds containing *Barrettia gigas* (Sabana Grande Formation) that occur west of Lajas.

The upper part of the sequence bears the rudist bivalve *Titanosarcolites,* generally accepted to be restricted to Maastrichtian deposits. Equivalent *Titanosarcolites*-bearing limestones are exposed in many outcrops north and east of this locality. The presence of *Chiapasella* in association with *Barrettia* in the lower



Text-figure 14.—Collection localities 18–22, Municipio de Lajas, Puerto Rico. Base from U.S. Geological Survey San German 7.5-minute quadrangle, scale 1:20,000, 1966.

part of this section presents an anomaly. In Jamaica, Cuba, and Mexico, *Chiapasella* seems to occur only at *Titanosarcolites*-bearing levels, all higher than those with *Barrettia.* However, in Jamaica, beds with *Barrettia* are usually separated from those with *Titanosarcolites* by a thick interval of volcaniclastic material lacking fossils. In Cuba and Mexico, rudist taxa are reported from numerous localities, but the stratigraphic relations between localities are less precisely known. Thus, the section given above may record a fossiliferous stratigraphic interval not seen elsewhere in the Caribbean province.

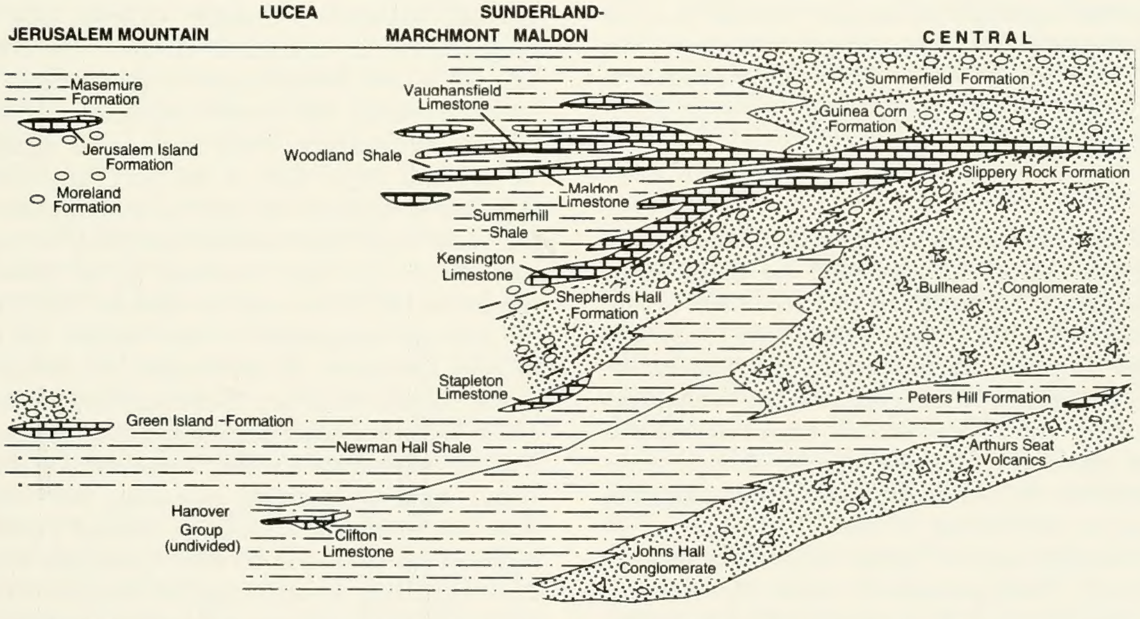
Jamaica

Trochacean gastropods are widely distributed in the Upper Cretaceous deposits of the western inliers of Jamaica. Their distribution is indicated by the locality numbers plotted on the map presented as Text-figure 2. A general overview of the geology of these deposits is presented in the explanation of the provisional geologic map of Jamaica prepared by Zans *et al.* (1962).

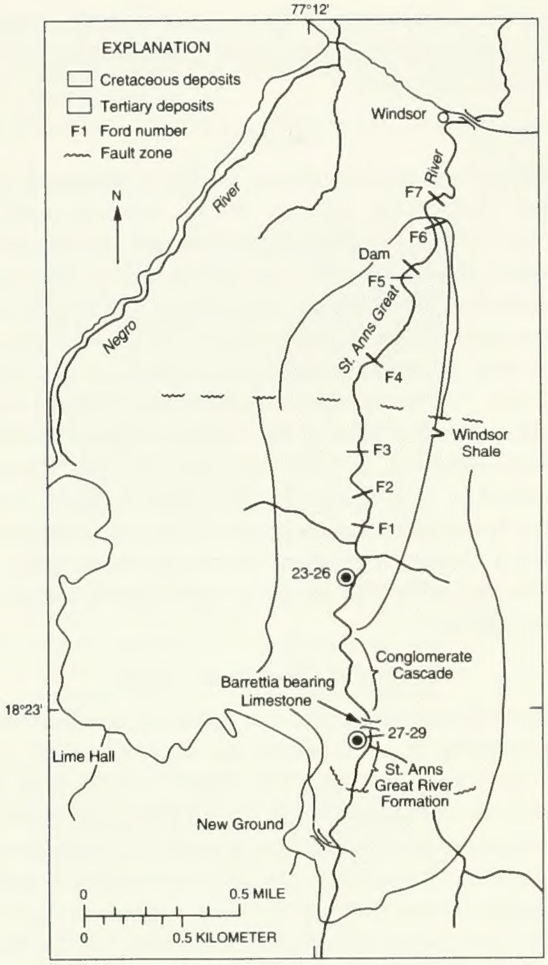
Coates (1977, fig. 5) provided a depositional model that links the sections of the various isolated inliers of western Jamaica. A modified form of that model is presented in Text-figure 15. This figure shows the increase in rudist framework limestones and interbedded lagoonal shales in sections westward from areas like the Central inlier that lie closer to volcanic debris dispersal centers.

St. Anns Great River Inlier

Upper Cretaceous rocks are exposed in a small inlier mainly along St. Anns Great River, south of St. Anns Bay (Text-figs. 2, 6, and 16). These are the only Cretaceous rocks exposed in St. Ann Parish and have special importance both because of their isolated position and because the section contains the oldest fossiliferous Upper Cretaceous (lower Coniacian) rocks in Jamaica west of the Wagwater Belt (Text-fig. 2). Sawkins (1869, p. 199) first noted the occurrence of these



Text-figure 15.—Diagrammatic reconstruction of relations among the Upper Cretaceous deposits of central and western Jamaica. The dominantly volcaniclastic sands, shales, conglomerate, and breccia sequences of the Central inlier are shown to grade westward into shelfal shales and carbonate platform, rudist-rich limestones, sands, and shale. Modified from Coates (1977).



Text-figure 16.—Collection localities 23–29, St. Anns Great River inlier, St. Ann Parish, Jamaica. Base after Greiner (1965). St. Anns Great River flows northward. Discontinuous exposures along the river of the Windsor Shale, Cascade Conglomerate, and St. Anns Great River Formation (including its basal unit, the *Barrettia*-bearing limestone) are labeled on the map and described in the text; Text-figure 6 shows the correlation of these units with other Cretaceous rocks in Jamaica.

rocks and referred them to the upper conglomerates of the Trappean Series. Subsequently, the basic stratigraphic sequence was outlined by Trechmann (1924, 1927) and Chubb (1955, 1956, 1958, 1959, 1962). The geographic tie points for the locality descriptions are shown on Text-figure 16 and consist of the two bridges over the river and seven fords; a major waterfall is below the southern bridge. Because no detailed maps are available for St. Ann Parish, latitude and longitude are not given for localities 23–29.

The lowest unit exposed in the inlier is the Windsor Shale (Chubb, 1962), presumably named for the Windsor Spring and Hotel at the northern end of the valley. The base of the unit is concealed by alluvium, but it is assumed to pass below the Tertiary White Limestone that crops out between river fords 6 and 7. The discontinuous exposures of the lower part of the Windsor Shale between ford 6 and the fault zone downstream of ford 3 consist dominantly of massive sandstone and conglomerate. The medial part is mainly dark-gray shale interbedded with thin beds of siltstone that grade upward into a sequence of grayish-brown silty shales that are carbonaceous in places. At the downstream end of the exposures immediately below ford 3, the shale is much sheared, and bedding is distorted. Locally, bedding becomes nearly vertical. This zone of deformation was considered by Chubb (1958) to be a major fault zone that brought Ceno-manian or Coniacian beds on the south into contact with Campanian beds of the Windsor Shale on the north (Chubb, 1962). Subsequently, Sohl (1976) reported the discovery of early Coniacian ammonites and inoceramid bivalves in a shale unit within the lower part of the Windsor Shale at a river bend below a house about 100 m upstream of ford 4 (Text-fig. 16). Esker (1969) reported late Coniacian foraminifers from shales immediately south of the fault, but Pessagno (1976) reinterpreted this find as early Santonian. This normal succession of dates from early Coniacian to late Coniacian across the fault zone indicates that the displacement of beds on the fault is not great.

South of the fault are exposures of the unit that previously was called the "Inoceramus shale" but that is included in the upper part of the Windsor Shale (see Jiang and Robinson, 1987). The "Inoceramus shale" consists of about 525 m of interbedded shale, siltstone, and conglomerate that are repetitive or cyclic in nature. Bedding thickness is highly variable, and the unit ranges from thin bedded to massive. The conglomerates range from pebbly shales to cobble beds. Volcanic rocks dominate the cobble fractions, but limestone pebbles and abraded fossil clasts occur mainly in the middle and upper part of the unit. Microfossils are scattered throughout the unit, but macrofossils, including some of the trochaceans described herein (localities 23–26), are most common in the shales of the upper one-half of the unit. Trechmann (1927) provided the first age assignment of these shales. On the basis of float specimens of *Inoceramus*, he placed the unit in the middle Senonian. Subsequently, Chubb (1955, 1956, 1962) provided shifting age assessments ranging from Cenomanian to the Turonian and Coniacian based upon inoceramid, ammonite, and foraminifer data and settled on a Turonian through Coniacian assignment in 1971. Esker (1969) presented foraminifer data suggesting an age range of late Coniacian at the base to early Campanian at the top for the shales north of the fault zone. Kauffman (1976), Sohl (1976), and Pessagno (1976) provided reassessments of the inoceramid, ammonite, and foraminifer data indicating that no Coniacian was present south of the fault zone and that most of the unit formerly called "Inoceramus shale" was Santonian ranging up into the Campanian.

The Cascade Conglomerate (Chubb, 1959) overlies the Windsor Shale. It is a massive volcanic conglomerate about 180 m thick whose resistant character forms a major waterfall and series of rapids in the stream below and downstream of an old bridge. The cobble- to boulder-size clasts are generally well rounded, but some zones approach a breccia. No fossils have been collected in the Cascade Conglomerate, and the upper contact with the overlying "Barrettia limestone" is obscured by a covered interval of about a meter.

The "Barrettia limestone" crops out in the streambed and in the roadbed leading to the bridge above the Cascade Conglomerate (Text-fig. 16) and is included as the basal unit of the St. Anns Great River Formation of Jiang and Robinson (1987). It consists of a lower 1-m-thick unit of poorly exposed, shaly, cobbly, bioclastic limestone that is overlain by 2 to 2.5 m of cobbly to massively bedded limestone. Finger corals are common in the lower part of the unit, but rudist bivalves, including rare specimens of *Barrettia gigas,* dominate in the upper part. Zans *et al.* (1962) reported that Bolli found Campanian foraminifers in shales about 15 m above the limestone, and Esker (1969) found similar foraminifers below it in the upper part of the "Inoceramus shale." Jiang and Robinson (1987) reported middle Campanian nannofossils from the "Barrettia limestone" interval of the St. Anns Great River Formation.

Trechmann (1924) recognized a fossiliferous shale unit overlying the *Barrettia*-bearing limestone. This shale was designated the "Diozoptyxis shale" by Chubb (1955, p. 187), who named it for "its most characteristic fossil *Diozoptyxis (Glauconia) matleyi* (Trechmann)." The name is unfortunate because the fossil is insufficiently preserved to merit assignment to either of the taxonomically unrelated genera. This unit is included as the upper part of the St. Anns Great River Formation (Chubb, 1955). The shale is well exposed in the river bed and consists of 25 to 30 m of gray shale that becomes more silty and sandy and less fossiliferous upward. The basal contact is gradational with the cobbly limestone below through an interval of calcarenitic shale. The upper contact is obscured by stream deposits.

The deposits above the St. Anns Great River Formation and below outcrops of the Yellow Limestone (early Tertiary) have been assigned to the New Ground Conglomerate (Chubb, 1962), a unit of possible post-Cretaceous age. The lowest unit exposed above the covered interval consists of a coarse-grained, grayish, crossbedded sandstone containing minor conglomeratic stringers. Upward the sandstone grades into about 100 m of coarse volcanic conglomerate, consisting of subangular to subrounded cobbles, that is capped by 1.5 m of brown, pebbly sandstone containing a few poorly preserved ostreid bivalves. The remainder of the unit consists of over 100 m of alternating thick units of massively bedded volcanic conglomerates, thinner gritty sandstones, siltstones, and a few carbonaceous mudstones.

From near the top of the New Ground Conglomerate, Esker (1969) reported a lower to middle Eocene planktonic foraminifer assemblage. The presence of these foraminifers, in addition to the report by Zans (*in* Chubb, 1959, p. 151; see also Greiner, 1965) of a fault about 0.4 km upstream of the *Barrettia*-bearing limestone (Text-fig. 16), suggests the possibility that the whole section above the St. Anns Great River Formation is post-Cretaceous.

Locality 23 and 24.—Windsor Shale. Exposures in low banks along west side of St. Anns Great River upstream from ford 1, both upstream (locality 24) and downstream (locality 23) of a point where a small tributary (not shown in Text-fig. 16) enters from the east, St. Ann Parish. Locality 23, USGS Mesozoic locality 29956 (collectors: N.F. Sohl, A.G. Coates, E.G. Kauffman, and J.E. Hazel, 1966). Locality 24, USGS Mesozoic locality 30064 (collectors: N.F. Sohl and W.O. Ross, 1971).

Collections were made from the upper part of the Windsor Shale in fossiliferous, dark-gray, sandy shale containing stringers of pebbles that are interbedded with well-indurated, unfossiliferous siltstones. This level is at the base of the so-called "Inoceramus shale" and lies about 300 m above the fault zone. Fossils occur as scattered individuals. Inoceramid bivalves and turritellid gastropods are the most common mollusks, but a few trochacean, neritid, aporrhaid, and other gastropods also occur, along with a few nuculid, ostreid, and other bivalves and rare corals.

Locality 25.—Windsor Shale. Exposures in the bed and banks of St. Anns Great River about 100 m upstream of localities 23 and 24 and 30 m stratigraphically higher (330 m above the base of the "Inoceramus shale"), St. Ann Parish. USGS Mesozoic locality 30065 (collectors: N.F. Sohl and W.O. Ross, 1971).

This collection was made from a silty mudstone containing inoceramid bivalves and common specimens of large cerithiacean gastropods.

Locality 26.—Windsor Shale. Locality same as for 25, but 7 m higher in the section, 337 m above the base of the "Inoceramus shale," St. Ann Parish. USGS Mesozoic locality 30066 (collectors: N.F. Sohl and W.O. Ross, 1971).

This collection was made from a thin zone of concentrated fossils containing a diverse assemblage of cerithiacean and other small mollusks.

Locality 27.—St. Anns Great River Formation. Exposures in the banks of St. Anns Great River, about 50 m upstream of the small bridge that crosses the river between the outcrops of the Cascade Conglomerate and the "Barrettia limestone," which is the basal unit of the St. Anns Great River Formation, St. Ann Parish. USGS Mesozoic locality 30502 (collectors: N.F. Sohl and W.O. Ross, 1972).

This collection was made from dark-gray shale, within the upper part of the St. Anns Great River Formation ("Diozoptyxis shale") and about 7 m above the "Barrettia limestone." The shale contains a diverse assemblage of small mollusks and common corals.

Locality 28.—St. Anns Great River Formation. Locality same as for 27, but from a calcarenitic shale within the upper part of the St. Anns Great River Formation ("Diozoptyxis shale"), about 3 to 4 m above the "Barrettia limestone," St. Ann Parish. USGS Mesozoic locality 30501 (collectors: N.F. Sohl and W.O. Ross, 1972).

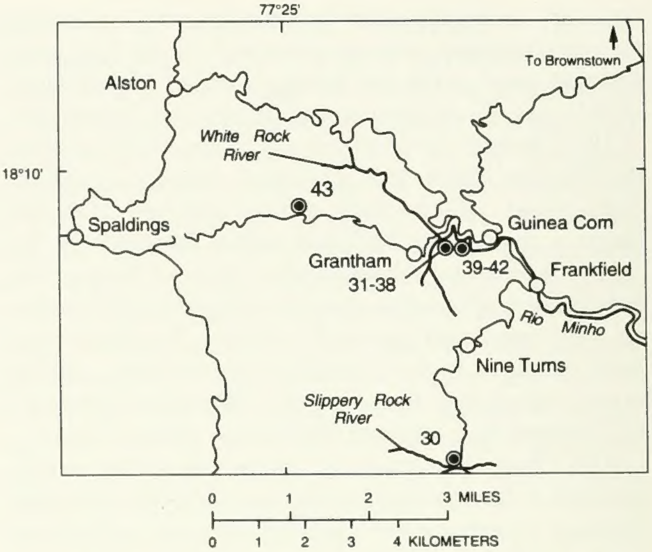
Locality 29.—St. Anns Great River Formation. Locality immediately upstream of locality 27 just below the point of entry of a tributary from the east, St. Ann Parish. USGS Mesozoic locality 29959 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966).

This collection was made from dark-gray shale of the St. Anns Great River Formation, in the lower part of the "Diozoptyxis shale" about 10 m above the base of the unit.

Central Inlier

The Central inlier (Text-fig. 2) occupies much of the area of Clarendon Parish and extends a short way east into the Parish of St. Catherine and west into Manchester Parish. Cretaceous rocks are exposed as the result of stripping of the Tertiary strata from the crest of a west-northwest-trending anticline (Robinson *et al.*, 1970).

Although Santonian to lower Campanian fossiliferous marine deposits (Peters Hill Formation) are known in the Central inlier, only younger Cretaceous limestones and shales of the upper part of the Slippery Rock Formation and the Guinea Corn Formation have yielded trochacean gastropods. The bed and bluffs of the Rio Minho west of Frankfield, in Clarendon Parish, provide virtually continuous exposures and, in the composite, a complete section through the Guinea Corn Formation (localities 31–42, Text-fig. 17). The section is dominated by alternating units of shale and limestone, and limestone becomes more massive and abundant in the upper one-third of the section. Rudist bivalves are the dominant elements in the limestone units, whereas nonrudist mollusks and corals are abundant in the shale units. The alternation of lithologies and faunas of parts of this section has been discussed by Kauffman and Sohl (1974, pp. 449–453, and fig. 22). Localities 31 to 38 are in the lower to middle part of the Guinea Corn Formation, and localities 39 to 42 are in the upper part of the formation.



Text-figure 17.—Collection localities 30–43, Central inlier, Clarendon Parish, Jamaica. Base from Chapleton, Jamaica, sheet (Great Britain Directorate of Overseas Surveys).

Locality 30.—Slippery Rock Formation. Bluffs along Slippery Rock River, upstream about 100–150 m from bridge of the Frankfield-to-Smithfield road and 2.57 km (airline) south of the church at Nine Turns, Clarendon Parish. Locality 30 is at lat 18° 06'40" N., long 77° 22'56" W. USGS Mesozoic locality 30032 (collectors: A.G. Coates, N.F. Sohl, and W.O. Ross, 1971).

This collection comes from the upper part of the Slippery Rock Formation (Robinson and others, 1970), in the part that is transitional to the overlying Guinea Corn Formation. The fossils occur in a gray, fine-grained sandstone that underlies a brown, laminated siltstone and consist of a molluscan assemblage including *Actaeonella duckettsensis* Sohl and Kollmann, 1985, trochacean and cerithiacean gastropods and *Brachidontes* sp., cardiids, and other pelecypods. Chocolate-brown shales, sandy shale, and conglomeratic beds occur below the fossiliferous interval. About 20 m higher in the section, massive limestones that contain abundant rudist bivalves, including *Titanosarcolites* sp., become prominent. These massive limestones belong to the Guinea Corn Formation.

Locality 31.—Guinea Corn Formation. Exposures of the Guinea Corn Formation in bed and bluffs along the course of the Rio Minho, from immediately upstream of the mouth of White Rock River (Rodons River in some usage) to several hundred meters downstream, about 2.25 km (airline) northwest of the bridge at Frankfield, Clarendon Parish. Locality 31 is at lat 18° 09'25" N., long 77°23'22" W. USGS Mesozoic locality 30042 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971).

This collection comes from a 1.2-m-thick shale about 13 m above the base of the formation in the lower part of the formation. This shale contains an abundance of solitary corals and both trochacean and cerithiacean gastropods. Both overlying and underlying units are limestones that contain abundant radiolitid rudist bivalves.

Locality 32.—Guinea Corn Formation. Location same as for locality 31, but from a 0.3-m-thick bed of gray shale about 11 m above the base of the formation in the lower part of the formation. USGS Mesozoic locality 30043 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971).

Locality 33.—Guinea Corn Formation. Location same as for locality 31, but from a 0.6-m-thick unit of blue-gray, silty mudstone 34.5 m above the base of the formation in the lower part of the formation. USGS Mesozoic locality 29972 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966).

Locality 34.—Guinea Corn Formation. Location same as for locality 31, but from a 0.5-m-thick bed of dark, blue-gray shale with carbonaceous streaks immediately overlying the silty mudstone of locality 33. USGS Mesozoic locality 29973 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966).

The collection from locality 34 contains a diverse assemblage of about 30 species of mollusks dominated by abundant *Trochactaeon* (*Mexicotrochactaeon*) *granthamensis* Sohl and Kollmann, 1985, *Actaeonella duckettsensis* Sohl and Kollmann, 1985, and undescribed turritellid gastropods.

Locality 35.—Guinea Corn Formation. Location same as for locality 31, but from a 4.5-m-thick dark, blue-gray shale with lignitic streaks, 48.5 m above the base of the formation in the lower to middle part of the formation. USGS Mesozoic locality 29978 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966).

This collection is especially noteworthy for the diversity of both gastropods and pelecypods represented. As in most of the shale units in the Guinea Corn Formation, rudist bivalves, except for clusters of the small shells of *Distafenella,* are rare or absent in the shale at locality 35. The following list provides a view of the spectrum of this diversity; infaunal forms are abundant. Such diversity in the shales is in stark contrast with the paucispecific or low diversity found in the rudist-dominated assemblages of the interbedded limestones (Kauffman and Sohl, 1974, fig. 22).

Gastropoda:

Metriomphalus sp.
Planolateralus sp.
Denticulabrum n. sp.
Tectus n. sp.
Camitia (Micatia) plicata Sohl, n. sp.
Rissoidae undet.
Pyrazus sp.
Pseudomalaxis sp.
Turritella spp.
Globularia sp.
Harpagodes n. sp.
Strombidae n. gen.
Xenophora sp.
Calyptraea sp.
Fusinid undet.
Volute undet.
Nerinella sp.
Actaeon sp.
Trochactaeon (*Mexicotrochactaeon*) *granthamensis* Sohl and Kollmann, 1985
T. (M.) burckhardti (Böse)
Actaeonella duckettsensis Sohl and Kollmann, 1985
Actaeonella marchmontensis Sohl and Kollmann, 1985
Ringicula (Ringicula) sp.

Pelecypoda:

Brachidontes sp.
Gervillia sp.
Lima sp.
Syncyclonema sp.
Neithea sp.
Lopha sp.
Ostrea sp.
Astarte sp.
Crassatella sp.
Lucina sp.
Parvilucina sp.
Tellina sp.
Protodonax sp.
Unicardium sp.
Glossocardia sp.
Aphrodina sp.
Legumen sp.
Solen? sp.
Anatimya sp.
Teredinid

Panopea sp.
Pholadomya sp.
Distafenella sp.

Locality 36.—Guinea Corn Formation. Location same as for locality 31, but from a 0.6-m-thick bed of dark, blue-gray shale containing limestone cobbles and common multicolumn asterid corals, about 53 m above the base of the formation in the middle part of the formation. USGS Mesozoic locality 30045 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971).

Locality 37.—Guinea Corn Formation. Location same as for locality 31, but from a 2.5-m-thick unit of silty, cobbly limestone containing common *Thyrastylon,* a few other rudist bivalves, and gastropods, about 54 m above the base of the formation in the middle part of the formation. USGS Mesozoic locality 30046 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971).

Locality 38.—Guinea Corn Formation. Location same as for locality 31, but from discontinuously exposed, fossiliferous, brownish shale containing a few limestone cobbles about 67 m above base of formation in the middle part of the formation. USGS Mesozoic locality 29981 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966).

Locality 39.—Guinea Corn Formation. Exposures in the bed and banks of the Rio Minho about 2 km N.30° W. of Frankfield Post Office, Clarendon Parish, in the upper part of the formation. Locality 39 is at lat 18° 09'19" N., long 77° 23'28" W. USGS Mesozoic locality 30058 (collectors: N.F. Sohl and W.O. Ross, 1971).

This collection is from a 0.6-m-thick bed of gray shale containing button corals and a moderate diversity of mollusks dominated by turritellids. The sample comes from about 75 m above the base of the formation and 82.6 m below the Summerfield Formation in the upper part of the Guinea Corn Formation.

Locality 40.—Guinea Corn Formation. Location same as for locality 39, but from a 0.9-m-thick gray, shaly, cobbly limestone bed containing actinacid corals and hipponicid gastropods, about 76.2 m above the base of the formation and 81.4 m below the Summerfield Formation in the upper part of the Guinea Corn Formation. USGS Mesozoic locality 30056 (collectors: N.F. Sohl and W.O. Ross, 1971).

Locality 41.—Guinea Corn Formation. Location slightly east of locality 39 at bend in river and from a 2.4-m-thick, blue-gray shale about 76 m above the base of the formation and in the upper part of the formation. USGS Mesozoic locality 30061 (collectors: N.F. Sohl and W.O. Ross, 1971).

Locality 42.—Guinea Corn Formation. Location same as for locality 41, but from a 2.4-m-thick, brownish hackly shale about 70.7 m above the base of the formation and in the upper part of the formation. USGS Mesozoic locality 30063 (collectors: N.F. Sohl and W.O. Ross, 1971).

Locality 43.—Guinea Corn Formation. Exposures in cuts of the Spaldings-to-Frankfield road near the 10.5 milepost about 2.09 km (airline) west-northwest of Grantham, Clarendon Parish (Text-fig. 17). Locality 43 is at lat 18° 09'35" N., long 77° 24'38" W. USGS Mesozoic locality 30040 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971).

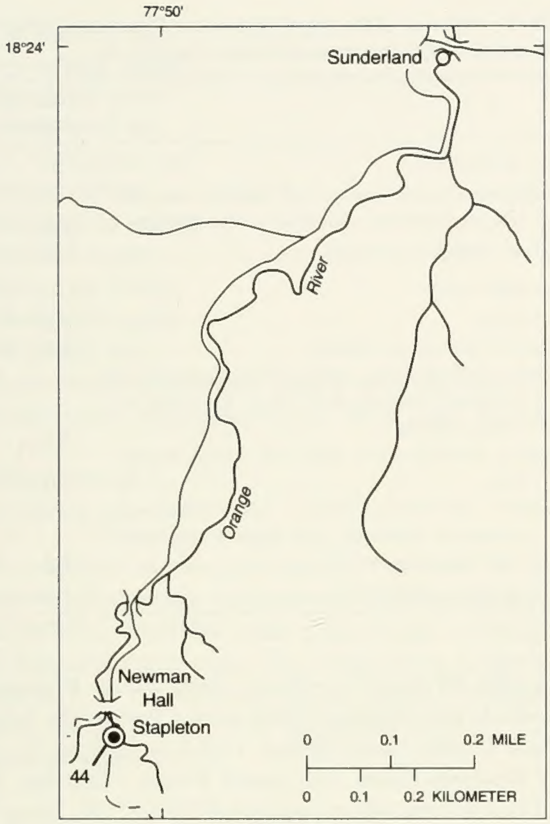
The roadcuts in the vicinity of locality 43 have been referred to as the Logie Green section in the literature. The light-gray, calcareous, nodular shales at this location contain an abundant assemblage of corals and mollusks and only rare specimens of rudist bivalves. The collection comes from the upper part of the formation. Associated beds commonly contain specimens of *Titanosarcolites,* indicating the equivalency of the Guinea Corn Formation to the *Titanosarcolites*-bearing limestones of the Maldon, Marchmont, and Jerusalem Mountain inliers to the west.

Sunderland Inlier

The Sunderland inlier lies a few kilometers southeast of Montego Bay (Text-fig. 2) in St. James Parish. Chubb (*in* Zans *et al.*, 1962) estimated that at least 2,300 m of Cretaceous deposits is exposed along a north-to-south traverse across this inlier. The basal unit, the Johns Hall Conglomerate, is a dominantly volcaniclastic unit containing minor interbeds and pods of shale of undetermined thickness. The overlying Sunderland Shale is mainly a silty shale containing a few beds of muddy sand. Inoceramid bivalves are the most prominent macrofossil in the unit. The succeeding Newman Hall Shale is a gray to olive-green mudstone containing occasional siltstone beds and concretions. Inoceramids occur at irregular intervals along with a few other bivalves; near the top of the unit, gastropods occur.

Chubb (*in* Zans *et al.*, 1962) estimated the two shale formations to aggregate 1,370 m in thickness. This may be an excessive approximation because I have noted several reversals in dip within these shales while traversing the outcrops along the Orange River (Text-fig. 18). The shale sequence is capped by a 7-m-thick unit of rudist-bearing limestone, cobbly limestone, and conglomeratic shale called the Stapleton Formation.

The overlying Shepherds Hall Formation is a sequence of varicolored volcanic conglomerates, mudstones, and sandstones about 800 m thick. Above these conglomerates, on the valley slopes north of Kensington, limestone float of a radiolitid limestone and free



Text-figure 18.—Collection locality 44, Sunderland inlier, St. James Parish, Jamaica. Base from land survey sheets 42A and 42C, Survey Department of Jamaica.

specimens of *Titanosarcolites* are found (Kensington Limestone).

The ages assigned to the various units in the Sunderland inlier have varied among workers on different groups of organisms. Chubb (1958) cited early Campanian planktonic foraminifers from the Johns Hall Conglomerate and the Sunderland Shale and late Campanian species from the Newman Hall Shale. On the basis of other foraminifer collections, Dommelen (1971) and Krijnen (1972) assigned the Sunderland to the late Campanian and early Maastrichtian and the Newman Hall to the Maastrichtian. Jiang and Robinson (1987) reported early Campanian nannofossils from the Sunderland and middle Campanian nannofossils from the Newman Hall.

Macrofossil ages differ to a minor degree. Kauffman (1966) found late Santonian to early Campanian inoceramids in the lower part of the Sunderland and found late Campanian inoceramids in the Newman Hall. Sohl (1968) noted Campanian mollusks from the Johns Hall. Obviously, these differences need to be resolved by further work.

In the Sunderland inlier, trochacean gastropods have been found only in the Stapleton Formation.

Table 4.—Section of part of the Stapleton Formation at locality 44. [Section initiated a meter or two above the *Barrettia*-bearing limestone exposed at the bridge at Stapleton (Text-fig. 18).]

	Thickness (meters)
Stapleton Formation:	
7. Shale, brownish-gray	2.5
6. Limestone, cobbly, containing worn clasts of rudist bivalves	0.6
5. Shale, gray, silty	0.3
4. Limestone, light-gray, massive, containing rare *Barrettia* near top	3.0
3. Shale, brownish-gray, silty	1.2
2. Limestone rubble with shaly matrix, mollusks abundant (locality 44; USGS Mesozoic localities 29939 and 30014); *Antillocaprina lowenstami* Chubb, 1971, *Antillosarcolites macgillavryi* Chubb, 1971, *Plagioptychus* sp., *Torreyites sanchezi* (Douvillé), 1927, *Plicatula* sp., *Spondylus* sp., *Lima* sp., *Syncyclonema* sp., *Neithea* sp., *Metriomphalus* sp., *Chilodonta* sp., *Stegnostomella* sp., *Actaeonella coquiensis* Sohl and Kollmann, 1985	0.4
1. Shale, brownish, and covered below to *Barrettia*-bearing limestone	1.4
Total Stapleton Formation	9.4

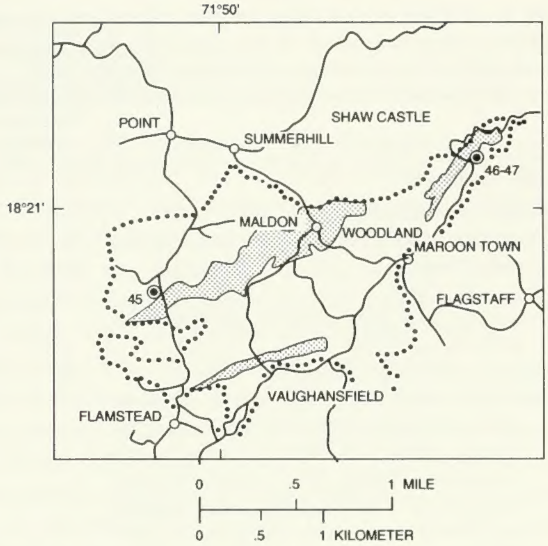
Locality 44.—Stapleton Formation. Exposure in cuts of the track from Stapleton to Kensington on north-facing slope of Orange River valley, immediately south of bridge at Stapleton and 2.4 km (airline) south-southeast of Sunderland Bridge, St. James Parish (Text-fig. 18). Locality 44 is at lat 18° 22'47" N., long 77° 50'07" W. USGS Mesozoic localities 29939 (collectors: N.F. Sohl, E.G. Kauffman, J.E. Hazel, and A.G. Coates, 1966) and 30014 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971). The stratigraphic position of locality 44 is indicated in Table 4.

The listed molluscan assemblage found in bed 2 of the section given above is duplicated in the limestones of the Green Island inlier to the west. *Barrettia gigas,* found in the underlying limestone, is also found in the limestones of the Green Island inlier and the St. Anns Great River section discussed above. These associations strongly suggest equivalency of the "Barrettia limestone" of the three sequences.

Although most recent workers have considered these limestones to be either upper Campanian or lower Maastrichtian, Jiang and Robinson (1987) cited middle Campanian nannofossils as occurring in units both below and above the Stapleton Formation.

Maldon Inlier

A few kilometers south of the Sunderland inlier, still within St. James Parish, another area of Cretaceous



Text-figure 19.—Collection localities 45–47, Maldon inlier, St. James Parish, Jamaica. Coarse dots enclose area of Cretaceous rock exposures, and stippled pattern indicates areas of limestone outcrop. Base from land survey sheets 42C, and 43A, Survey Department of Jamaica.

rocks is exposed. This area is called the Maldon inlier (Text-fig. 2). The Cretaceous of the Maldon inlier may be viewed as a stratigraphically higher continuation of the Sunderland inlier sequence, as all units of the Maldon inlier lie within the range zone of *Titanosarcolites*. The outlines of the Cretaceous succession in the Maldon inlier (Text-fig. 19), were provided by Chubb (1958), who estimated the section to be about 475 m thick. Chubb (1971) revised the formation nomenclature (Text-fig. 6).

The section consists of a sequence of alternating shales and limestones with local units of conglomerate. The limestones bear an abundant rudist bivalve assemblage, examples of which have been illustrated by Kauffman and Sohl (1974, figs. 15a, 15b, 18a, 19). The shales, at least locally, contain a varied molluscan assemblage (see list below for unit 3, locality 46). Some of the limestone units appear to grade laterally into shale, but the Maldon Limestone seems persistent across the inlier.

Trochacean gastropods have been found at only two localities in the inlier, but this rarity reflects lack of collecting in the shale units more than true scarcity.

Locality 45.—Summerhill Shale. Exposures in roadcut of the road from Point to Flamstead, 1.93 km (airline) north of the crossroads at Flamstead, St. James Parish (Text-fig. 19). Locality 45 is at lat 18° 20'25" N., long 77° 49'24" W. USGS Mesozoic locality 30023 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971). The stratigraphic position of locality 45 is indicated in Table 5.

Table 5.—Section of the upper part of the Summerhill Shale and lowermost Maldon Limestone exposed at locality 45.

	Thickness (meters)
Maldon Limestone:	
6. Limestone, gray, marly, well-bedded, and containing abundant radiolitid rudist bivalves	2.0
Total Madon Limestone	2.0
Summerhill Shale:	
5. Covered	3.0
4. Shale, red-brown, blocky	1.0
3. Shale, yellowish-tan, silty, containing abundant mollusks (locality 45; USGS Mesozoic locality 30023)	0.3
2. Shale, mottled red to yellowish brown, blocky, silty	1.2
1. Shale, red-brown, blocky, silty, containing abundant mollusks and large foraminifers near top of interval	1.5
Total Summerhill Shale	7.0

Locality 46 and 47.—Shaw Castle Shale. Exposures in roadcuts and adjacent fields near Chatsworth School at Shaw Castle Land Office, 1.45 km (airline) N. 33° E. of Maroon Town, St. James Parish (Text-fig. 19). Localities 46 and 47 are at lat 18° 21'25" N., long 77° 47'17" W. Locality 46, USGS Mesozoic localities 29955 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966) and 30017 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971). Locality 47, USGS Mesozoic locality 30018 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971). Stratigraphic positions of localities 46 and 47 are indicated in Table 6.

Unit 3 of the section in Table 6 contains especially abundant and diverse gastropods, mainly undescribed, but includes the following:

Diodora hazeli Sohl, 1992
Metriomphalus sp.
Arene truncatosphaera n. sp.
Chilodonta sp.
Denticulabrum laevigatum n. sp.
Nerita sp.
Turritella spp.
Procerithidae undet.
Pyrazus sp.
cf. *Tympanotonus* sp.
Potamididae undet.
Cerithiella sp.
Cerithiopsis sp.
cf. *Libycerithium* sp.
Cerithiidae spp.
Mirarissoina sp.
Avelana? sp.

Calyptraea sp.
Aporrhaid undet.
Strombid undet.
Globularia sp.
cf. *Cymatium* sp.
Bellifusus sp.
Fasciolarid undet.
Volutid undet.
Epitoniid undet.
Mathildid undet.
Nerinella sp.
Actaeonella coquiensis Sohl and Kollmann, 1985
Actaeonella marchmontensis Sohl and Kollmann, 1985
Ringicula sp.
Cylichna sp.

In addition to the gastropods, the shale of unit 3 contains pelecypods, scaphopods, chitons, corals, echinoid debris, serpulids, crab parts, large foraminifers, and dasycladacean alga. The corals bear a strong resemblance to those from the El Rayo Formation of Puerto Rico (locality 14) according to A.G. Coates (oral commun., 1971).

Marchmont Inlier

The Marchmont inlier of Cretaceous rocks (Text-fig. 20) is in Westmoreland Parish. Relatively little information has been published upon the character of the Cretaceous section or the nature of the fauna present in the Marchmont inlier. Trechmann (1927) commented upon the presence of a rudist limestone and a section of underlying shale exposed in cuts of the railway from Cambridge to Catadupa in the northern part of the inlier. Chubb (1955 and *in* Zans *et al.*, 1962) gave short summaries of the geology indicating that several limestones were present and that they all yielded a fauna including *Titanosarcolites* that he correlated with the succession of the Maldon inlier. Jiang and Robinson (1987) reported middle to late Campanian nannofossils from 24 samples from unspecified intervals within the inlier.

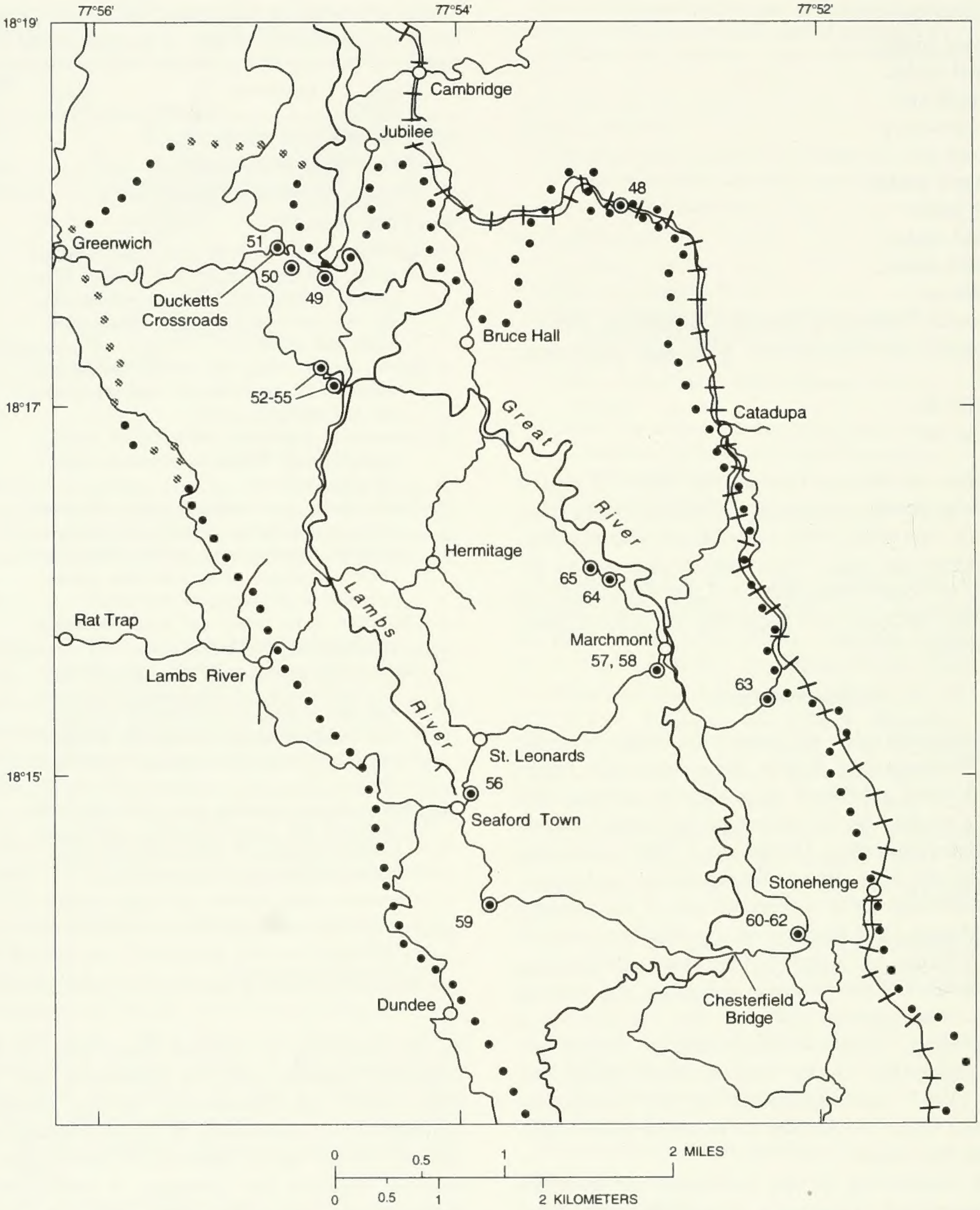
In their discussions of the evolution of Antillean rudist framework structures, Kauffman and Sohl (1974, figs. 17, 20, 22, 23) presented several stratigraphic sections and other illustrations taken from exposures of the Cretaceous rocks of the Marchmont inlier.

Because a number of faults divide the inlier into a series of blocks, the succession in the inlier is unclear, and only detailed mapping will provide a clear picture. However, reconnaissance traverses do indicate that the section is composed of a number of limestones separated by fine-grained clastic deposits. For example, in the St. Leonards to Seaford Town area, at least four limestone deposits may be delineated, and the same holds true in the Marchmont vicinity. Whether these limestones are continuous or grade laterally into fine-grained clastic facies needs to be determined. Carbonaceous adjuncts are common to these fine-grained clastic layers along with some thin sand partings or lentils. The limestones range from massive, gray, fine-grained limestone to bioclastic and rudist framework beds. *Biradiolites* spp. are common rudist framework builders, but locally *Thyrastylon* or *Chiapasella* may be the main constructional element. *Titanosarcolites* or *Antillocaprina* are major constituents in the more rubbly limestones.

Table 6.—Section of Shaw Castle Shale measured along roadcut and upward on adjacent hill slope at localities 46 and 47.

	Thickness (meters)
Popkin Volcanic Conglomerate(?):	
9. Shale, reddish, much weathered	12.0
Total Popkin Volcanic Conglomerate	12.0
Shaw Castle Shale:	
8. Limestone, gray, massive, and ledge-forming, discontinuously exposed; mainly fine grained to bioclastic, but some beds in middle and near top rich in *Titanosarcolites*, coral, and radiolites	12.8
7. Shale, brown, marly to rubbly, containing abundant *Plagioptychus* sp., branching corals, and stromatoporoids	0.4
6. Limestone, light-gray, massive to rubbly, ledge-forming, containing abundant radiolitid pelecypods	1.4
5. Shale, brown with reddish streaks, silty and marly, fossiliferous; *Titanosarcolites* especially abundant near middle, *Plagioptychus* sp. common, along with other pelecypods and some gastropods and corals	0.8
4. Limestone, gray, marly and silty, containing abundant radiolitid rudists	0.4
3. Shale, brown, marly to rubbly, with abundant *Titanosarcolites* and *Plagioptychus* in lower part, but gastropods and solitary and colonial corals abundant throughout (locality 46; USGS Mesozoic localities 29955 and 30017)	1.1
2. Mainly covered, probably shale, with abundant mollusks and corals weathering out on the surface (locality 47; USGS Mesozoic locality 30018 from upper part of interval	14.4
1. Limestone, gray, massive and ledge-forming, containing many radiolitid rudist framework beds	5.3
Total Shaw Castle Shale	36.2

The fauna within the fine-grained clastic deposits is more variable. In the western part of the inlier, in the area between Ducketts Crossroads and Lambs River



Text-figure 20.—Collection localities 48–65, Marchmont inlier, Westmoreland Parish and St. James Parish, Jamaica; the Great River is the boundary between the two parishes. Coarse dots enclose area of Cretaceous rock exposures; shaded dots indicate where the boundary is uncertain. Base from land survey sheets 33B, 33D, and 43C, Survey Department of Jamaica.

and thence to St. Leonards (Text-fig. 20), many of the reddish mudstones and shales contain distinctive, low-diversity, molluscan assemblages. Diminutive ostreids or venericardiid bivalves commonly dominate the associations in individual beds. Locally, brackish-water or even terrestrial gastropods are intermixed with more fully marine mollusks, and, in places, charophytes are abundant.

Elsewhere, to the east and north, brown, yellowish-brown, and gray shales occur interbedded with the limestones and contain a more diverse molluscan assemblage that lacks intermixture of the marginal marine elements. The trochacean gastropods described here occur mainly in these shale interbeds.

Locality 48.—"Titanosarcolites limestone." Limestones exposed in St. James Parish in cuts of the railway from Cambridge to Catadupa, about 2.4 km (airline) southeast of the railway station in Cambridge. Locality 48 is at lat 18° 18'03" N., long 77° 53'03" W. USGS Mesozoic locality 29904 (collectors: N.F. Sohl, A.G. Coates, E.G. Kauffman, and J.E. Hazel, 1966).

The gastropods occur in a cobbly limestone unit associated with the rudist bivalve *Titanosarcolites giganteus.*

Locality 49.—"Titanosarcolites limestone." Exposures in Westmoreland Parish in cuts of the road from Cambridge to Lambs River at Ducketts Crossroads, 2.17 km (airline) south-southwest of the railway station in Cambridge. Locality 49 is at lat 18°17'43" N., long 77° 54'46" W. USGS Mesozoic locality 30026 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971).

Nearly 2.5 m of reddish-gray shales is exposed in a cut on the east side of the road at the crossroads. Thin zones of fossil hash and carbonaceous matter occur at several levels. Fossils occur both scattered and in thin zones. Pelecypods outnumber gastropods, but about 30 species of snails are present; *Actaeonella* and *Turritella* are the most abundant. Echinoids, worm tubes, bryozoans, and a few corals are also present. These shales underlie a sequence of rudist-rich limestone exposed on the hill slopes west of the road.

Locality 50.—"Titanosarcolites limestone." Exposures in fields south of road from Greenwich to Ducketts Crossroads and about 300 m west of the intersection on west side of hairpin bend in road, Westmoreland Parish. Locality 50 is at lat 18° 17'44" N., long 77° 54'52" W. USGS Mesozoic locality 29914 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966).

This collection is from limestones stratigraphically higher than the shales of locality 49.

Locality 51.—"Titanosarcolites limestone." Exposures at hairpin bend in the road from Greenwich to Ducketts Crossroads, 0.32 km (airline) W. 20° N. of Ducketts Crossroads, Westmoreland Parish. Locality 51 is at lat 18° 17'46" N., long 77° 54'55" W. USGS Mesozoic localities 29925 (collectors: N.F. Sohl, E.G. Kauffman, A.G. Coates, and J.E. Hazel, 1966) and 30027 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971). Table 7 shows the section measured at locality 51 lies at least 36 m stratigraphically above the shales of locality 49.

Table 7.—Section of "Titanosarcolites limestone" at locality 51.

	Thickness (meters)
"Titanosarcolites limestone":	
3. Limestone, gray, rubbly to massively bedded; lower beds contain abundant *Antillocaprina* and corals; upper beds contain abundant radiolitid rudists in growth position	1.2
2. Marl, yellowish-tan, calcarenitic, containing abundant fossils; rudist bivalve clusters of *Thyrastylon* and *Biradiolites* occur scattered through unit along with a diverse assemblage of other pelecypods and gastropods. Among the gastropods, *Discotectus, Turritella,* and *Actaeonella* are especially common (locality 51; USGS Mesozoic localities 29925 and 30027	0.6
1. Limestone, gray, massive, fossiliferous; corals abundant near base, becoming a *Biradiolites* framework above..............................	1.6
Total "Titanosarcolites limestone"	3.4

Locality 52 through 55.—"Titanosarcolites limestone." Exposures in stream banks and bluffs along a generally east flowing tributary of the Great River beginning near bridge of the Lambs River road 1.2 km (airline) south of Ducketts Crossroads and extending upstream, from lat 18° 17'03" N., long 77° 54'36" W., to lat 18° 17'10" N., long 77° 54'43" W., Westmoreland Parish. Locality 52, USGS Mesozoic localities 30030 (collectors: N.F. Sohl, W.O. Ross, and A.G. Coates, 1971) and 30450 (collectors: N.F. Sohl and E.G. Kauffman, 1971). Locality 53, USGS Mesozoic locality 30451 (collectors: N.F. Sohl and E.G. Kauffman, 1971). Locality 54, USGS Mesozoic locality 33371 (collector: A.G. Coates, 1963). Locality 55, USGS Mesozoic locality 33372 (collector: A.G. Coates, 1963). Stratigraphic positions of localities 52–55 are indicated in the measured section in Table 8.

Locality 56.—"Titanosarcolites limestone." Exposures in cuts of the road from Seaford Town to St. Leonards, 0.3 km (airline) east-northeast of the road junction in Seaford Town, Westmoreland Parish. Locality 56 is at lat 18° 14'53" N., long 77° 53'56" W. USGS Mesozoic locality 30461 (collectors: N.F. Sohl and E.G. Kauffman, 1972).

The collection comes from a 2.1-m-thick unit of yellowish-brown shale, containing an abundant molluscan and coral fauna. Thin (0.4-m-thick) beds of gray fragmental limestone containing unoriented radiolitid bivalves overlie and underlie the shale.

Locality 57 and 58.—"Titanosarcolites limestone." Exposures of limestone and shale in cuts of the road from St. Leonards to Marchmont at south edge of Marchmont or 0.16 km (airline) south of the road intersection in Marchmont, Westmoreland Parish. Localities 57 and 58 are at lat 18° 15'34" N., long 77°

Table 8.—Composite section of "Titanosarcolites limestone" measured along tributary of the Great River (localities 52–55).

	Thickness (meters)
"Titanosarcolites limestone":	
11. Limestone, gray, rubbly, with fragmental rudist bivalves and rare regular echinoids	2.1
10. Limestone, light-gray, containing abundant *Titanosarcolites, Antillocaprina,* and clusters of *Biradiolites jamaicensis*	3.0
9. Partly covered, with a 0.2-m-thick bed of silty mudstone containing abundant small mollusks (locality 54; USGS Mesozoic locality 33371) in upper part and a 0.6-m-thick silty mudstone bed containing corals in lower part	3.0
8. Limestone, gray, with a *Biradiolites-* and *Thyrastylon*-framework bed at top underlain by a framework bed consisting of *Biradiolites* and *Chiapasella*	3.0
7. Mudstone, reddish-brown and gray, silty, discontinuously exposed, containing *Antillocaprina, Thyrastylon,* and multicolumn astreid corals in upper part and *Plicatula* and other bivalves and gastropods below	3.6
6. Limestone, gray, cobbly, containing common *Titanosarcolites*	1.8
5. Mudstone, reddish-brown, containing carbonaceous zones	2.1
4. Shale, gray, calcareous, nodular, fossiliferous; abundant ostreid bivalves and other mollusks (locality 53; USGS Mesozoic locality 30451)	1.2
3. Mudstone, gray, unfossiliferous	0.3
2. Shale, gray, calcareous, fossiliferous; abundant ostreid bivalves (locality 55; USGS Mesozoic locality 33372)	1.0
1. Sandstone, brownish, silty, containing common *Antillocaprina* and a diverse assemblage of other pelecypods, gastropods, and corals (locality 52; USGS Mesozoic localities 30030 and 30450)	1.2
Total "Titanosarcolites limestone"	22.3

52'53" W. Locality 57, USGS Mesozoic locality 30466 (collectors: N.F. Sohl and E.G. Kauffman, 1972). Locality 58, USGS Mesozoic locality 30467 (collectors: N.F. Sohl and E.G. Kauffman, 1972).

The exposed section consists of 6 m of shale overlain by 1.5 m of a radiolite-rich limestone. The dominant radiolitid forming the framework is *Thyrastylon*; a few adjunct *Sauvagesia* are present.

The collection from USGS Mesozoic locality 30466 (locality 57) comes from a reddish-brown shale in the lower part of the section in which the fossils are concentrated in thin zones. Most fossils are small; the most common gastropods are trochaceans, turritellids, and cerithiaceans. Pelecypods are moderately common, and rare fossils include large foraminifers and dasycladacean alga. The collection from USGS Mesozoic locality 30467 (locality 58) was made from the upper part of the shale, which is yellowish gray. The gastropods *Discotectus, Cerithium,* and *Actaeonella* are most common. Pelecypods are common; ostracodes and larger foraminifers are abundant. In all, the upper part has a more diverse assemblage than the lower part of the shale.

Table 9.—Section of the "Titanosarcolites limestone" measured in roadcuts south of Seaford Town at locality 59.

	Thickness (meters)
"Titanosarcolites limestone":	
6. Limestone, gray, in massive hard to cobbly and nodular beds, fossiliferous; radiolitid rudist bivalves common along with numerous corals	6.1
5. Mudstone, gray, blocky, containing scattered mollusks, large foraminifers, and plant debris	1.5
4. Mudstone, brownish-gray, containing abundant finger corals	0.5
3. Mudstone, brownish, containing abundant trochid, turritellid, and naticid gastropods, ostreid bivalves, and large foraminifers (locality 59; USGS Mesozoic locality 30471)	1.8
2. Clay, gray, silty and very sandy (tuffaceous), containing sparse fossils	0.9
1. Shale, reddish, carbonaceous (poorly exposed)	2.1
Total "Titanosarcolites limestone"	12.9

Locality 59.—"Titanosarcolites limestone." Exposures in cuts of the road from Seaford Town to Chesterfield Bridge, 0.93 km (airline) south of road intersection in Seaford Town, Westmoreland Parish. Locality 59 is at lat 18° 14'18" N., long 77° 53'52" W. USGS Mesozoic locality 30471 (collectors: N.F. Sohl and E.G. Kauffman, 1972). The stratigraphic position of locality 59 is indicated in the measured section in Table 9.

Locality 60, 61, and 62.—"Titanosarcolites limestone." Exposures of shale in St. James Parish along the road from Cambridge to Chesterfield Bridge, 3.2 km (airline) southeast of the road intersection in Marchmont. Localities 60–62 are at lat 18° 14'05" N., long 77° 52'06" W. Locality 60, USGS Mesozoic locality 30484 (collectors: N.F. Sohl and E.G. Kauffman, 1972). Locality 61, USGS Mesozoic locality 30482 (collectors: N.F. Sohl and E.G. Kauffman, 1972). Locality 62, USGS Mesozoic locality 30483 (collectors: N.F. Sohl and E.G. Kauffman, 1972).

The collections were made from a 5.0-m-thick section exposed in the roadcut at this locality as follows: USGS Mesozoic locality 30484 (locality 60) is in a black clay in the basal 1.5 m. USGS Mesozoic locality

30482 (locality 61) is in the overlying 1.4 m of gray, muddy fossil hash in which the gastropods *Discotectus* and *Turritella* are especially common; the occurrence of common small brachiopods is especially noteworthy in this unit. USGS Mesozoic locality 30483 (locality 62) is in 1.5 m of gray, silty shale overlying the preceding and containing a modest diversity of mollusks. The section is capped by 0.6 m of muddy sand containing a hash of oyster fragments.

Locality 63.—"Titanosarcolites limestone." Exposures in St. James Parish in cut of the road from Catadupa to Chesterfield Bridge, 1.0 km (airline) southeast of the road intersection in Marchmont. Locality 63 is at lat 18° 15'19" N., long 77° 52'22" W. USGS Mesozoic locality 31367 (collectors: E.G. Kauffman and N.F. Sohl, 1972).

Collections were made from the 1.8 m of reddish-brown shale exposed below the radiolitid- and *Titanosarcolites*-rich limestone exposed at this locality. The mollusk assemblage contains relatively few gastropods but is dominated by abundant clusters of ostreid bivalves and numerous *Brachidontes*.

Locality 64.—"Titanosarcolites limestone." Exposures in Westmoreland Parish in cuts along the road from Marchmont to Cambridge, 1.1 km (airline) northwest of the road intersection in Marchmont. Locality 64 is at lat 18°16'03" N., long 77° 53'12" W. USGS Mesozoic locality 30491 (collectors: N.F. Sohl and E.G. Kauffman, 1972).

This collection was made from a 0.3-m-thick unit of resistant sandy claystone at the base of the 2-m-thick exposure. This unit is overlain by 0.6 m of oyster-rich silty shale, which is overlain by 0.9 m of unfossiliferous, yellow-brown sandy shale. Among the gastropods, turritellids and cerithiaceans are abundant; ostreids are the most common among the pelecypods. Of the nonmolluscan fossils, the operculate worm *Hamulus* is especially common.

Locality 65.—"Titanosarcolites limestone." Exposures in Westmoreland Parish along the road from Marchmont to Cambridge, 1.2 km (airline) northwest of Marchmont. Locality 65 is at lat 18° 16'09"N., long 77° 53'19" W. USGS Mesozoic locality 30493 (collectors: N.F. Sohl and E.G. Kauffman, 1972).

The collection from USGS Mesozoic locality 30493 (field number J–72–23) comes from a sandy calcarenite bed near the middle of a 3.0-m-thick section of shale exposed at this locality. The assemblage is noteworthy for the dominance of infaunal bivalves, especially *Trigonia,* among the pelecypods. Gastropods are moderately diverse, and turritellids and aporrhaids are among the most common elements.

Lucea Inlier

The rocks of the Lucea inlier of Hanover Parish have been estimated to exceed 4 km in thickness (Grippi, 1980). They consist mainly of siltstone and shale, but sandstone is common, and the inlier also contains lesser amounts of conglomerate and minor lenses of limestone. Successive mapping efforts within the inlier (Bateson, 1974; Grippi, 1980) have led to recognition of as many as 13 separate formations of the Hanover Group to replace the old, all-inclusive, Hanover Shales designation (Chubb, *in* Zans *et al.*, 1962) for the Cretaceous rocks of this area. The shales and limestones of the inlier have yielded scattered fossils that have been reported on by Kauffman (1966), Chubb (1971), Grippi (1980), and Jiang and Robinson (1987). In sum, the various inoceramid bivalves, rudist pelecypods, and nannofossils suggest that the rocks of the Lucea inlier range from at least Santonian to middle and perhaps upper Campanian. Additional data on planktonic foraminifers are given below in the discussions of the localities that have yielded trochacean gastropods. The general position of the Lucea inlier and localities 66–68 can be seen on Text-figure 2; no detailed maps are available for this area of Jamaica because of cloud cover recorded on images from which maps would have been made.

Locality 66.—Askenish Formation. Cut bluff along the Askenish road between Dundee Pen and Johnson Town road intersection, 2.25 km (airline), E. 44° S. of Askenish, Hanover Parish. Locality 66 is at lat 18° 25'14" N., long 78° 09'10" W. USGS Mesozoic locality 29902 (collectors: N.F. Sohl., A.G. Coates, E.G. Kauffman, and J.E. Hazel, 1966).

About 9 m of black, silty shale and resistant interbeds of siltstone of the Askenish Formation is exposed at this locality. Small mollusks and rare corals are scattered through the mudstone but are absent from the siltstone. Fragmentary inoceramids occur at this locality but are indeterminate. Elsewhere in the formation, the Santonian to early Campanian species *Platyceramus cycloides cycloides* (Wegner, 1905), has been found by Grippi (1980, p. 6).

Locality 67.—Askenish Formation. Locality same as for locality 66, but from the lower 2.5 m of shale. USGS Mesozoic locality 30425 (collectors: N.F. Sohl and E.G. Kauffman, 1971).

In addition to over 30 species of mollusks, this collection contained a planktonic foraminifer assemblage identified by C.C. Smith (written commun., 1975) as follows:

Planoglobulina glabrata (Cushman)
Gubulerina cf. *G. deflaensis* (Sigal)
G. cf. *G. decoratissima* (de Klosz)

Heterohelix reussi (Cushman)
H. globulosa (Ehrenberg)
Globigerinelloides ehrenbergi (Barr)
G. asperus (Ehrenberg)
Globotruncana concavata (Brotzen)
G. fornicata Plummer
G. cf. *G. rosetta* (Carsey)
G. linneiana (d'Orbigny)
G. loeblichi Pessagno
G. stuartiformis Dalbiez
G. lapparenti (Brotzen)
G. bulloides Yegler
Rugotruncana tradinghousensis Pessagno
Archaeoglobigerina cf. *A. blowi* Pessagno
A. cretacea (d'Orbigny)

This assemblage was assigned by Smith to the upper part of the *Marginotruncana concavata* Subzone, similar to faunas from the upper part of the Dessau Formation and lower part of the Burditt Formation, both of the Austin Group of Texas. These Texas units are currently considered lowermost Campanian.

Locality 68.--Georgia Complex of the Hanover Group. Cut along the road from Cascade to Jericho, 0.96 km (airline) northwest of Cascade, Hanover Parish. Locality 68 is at lat 18° 23'52" N., long 78° 06'31" W. USGS Mesozoic locality 30437 (collectors: N.F. Sohl and E.G. Kauffman, 1971).

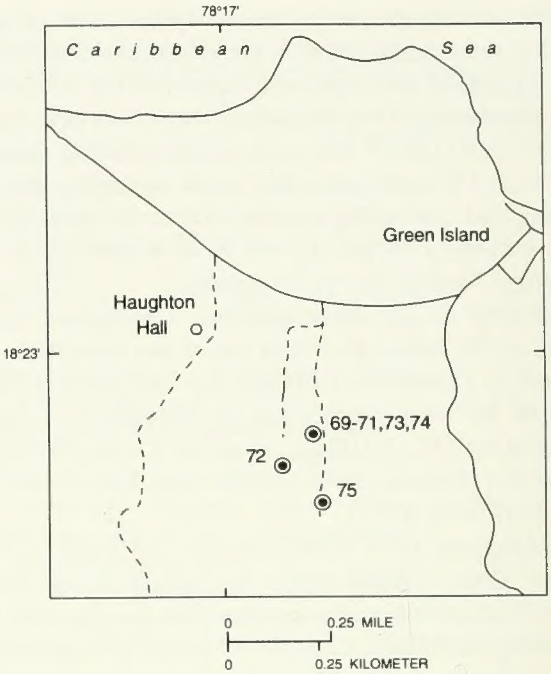
Grippi's (1980) map shows this outcrop to be within the Georgia Complex. The section consists of interbedded sandstone and shale. One lens consists of a conglomerate composed of small limestone pebbles, fragmentary mollusks, and one coral. No foraminifers were found in the shale at this locality, but, a short distance to the northwest (1.1 km airline from Cascade) along the same road, shale yielded a planktonic foraminifer assemblage that, according to C.C. Smith, is assignable to the lower Campanian.

The presence of diverse foraminifer assemblages in the few units sampled suggests that much more biostratigraphic information could be acquired from this inlier than currently exists.

Green Island Inlier

The Green Island inlier (Text-fig. 2) lies in the northwest part of the island in Hanover Parish, west-southwest of the village of Green Island. It is a small inlier of only a few square kilometers but has been known since Sawkins' (1869) early discussions on the geology of the island.

Trechmann (1922) interpreted the Cretaceous sequence of the inlier to consist of a lower unit of shale and sandstone with minor limestone beds, overlain by a *Barrettia*-bearing limestone with a conglomerate capping the section. He estimated the total section to have a maximum thickness of 36 m. Giles (1977) recognized a similar succession but estimated the section to have a maximum thickness of about 130 m. The trochacean gastropods described herein all come from the middle unit of lenticular limestones and yellowish-brown shales, the "Barrettia limestone" of early reports, which is equivalent to the Green Island Formation of Giles (1977). Rudist pelecypods from this unit have been described by Whitfield (1897), Trechmann (1922), and Chubb (1967, 1971), and other mollusks, mainly from the shales, by Trechmann (1927) and Sohl and Kollmann (1985). The unit falls within the range zone of *Barrettia gigas* that most workers have considered as late Campanian or early Maastrichtian. Jiang and Robinson (1987), however, suggested that the unit is upper middle Campanian.



Text-figure 21.—Collection localities 69–75, Green Island inlier, Hanover Parish, Jamaica. Base from land survey sheets 12B and 12D, Survey Department of Jamaica.

Locality 69.—Green Island Formation. Track through cane field on west-facing slope of north-trending valley 0.95 km S. 40° W. of Green Island, Hanover Parish (Text-fig. 21). Locality 69 is at lat 18° 22'47" N., long 78° 16'52" W. USGS Mesozoic localities 30006 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971) and 30429 (collectors: N.F. Sohl and E.G. Kauffman, 1971).

About 0.6 m of brownish shale containing a concentration of *Antillocaprina* is exposed in a low cut of the cane-field track. This shale lies some 15 m below the radiolitid limestone that caps the ridge.

Locality 70.—Green Island Formation. Locality same as for 69, but from a unit about 2.4 m stratigraphically above the latter. USGS Mesozoic locality 30430 (collectors: N.F. Sohl and E.G. Kauffman, 1971).

A thin (0.3 m) unit of yellowish-brown shale is exposed on the hill slope above the *Antillocaprina*-bearing shale of locality 69. Bioclasts to 2.5 cm in diameter are common. The shale contains a diverse molluscan assemblage in which *Durania nicholasi* is abundant and *Plicatula* sp. is common. Other species are represented by few individuals.

Locality 71.—Green Island Formation. Locality along same hill slope as localities 69 and 70, but slightly to the north at lat 18° 22'49" N., long 78° 16'49" W. USGS Mesozoic locality 30000 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971).

Collection was made of specimens weathering from poorly exposed shales that lie below the radiolitid limestone that caps the ridge. A moderately diverse group of gastropods occurs in the assemblage, including common trochaceans, cerithiaceans, naticids, and a few neogastropods. In addition, corals are common, and a few serpulids are present.

Locality 72.—Green Island Formation. East-facing slopes of north-trending valley, west-southwest of Green Island, Hanover Parish. Locality 72 is at lat 18° 22'51" N., long 78° 16'52" W. USGS Mesozoic locality 30009 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971).

Exposures of shale occur between 15 and 20 m below the radiolitid limestone that caps the north-trending ridge. The stratigraphic level is about the same as that of locality 71 to the east.

Locality 73.—Green Island Formation. Locality same as for 71, but from about 8 m stratigraphically higher. USGS Mesozoic locality 30001 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971).

Locality 74.—Green Island Formation. Locality virtually same as for 71, but from between a lower limestone on the hill slope and the radiolitid limestone that caps the ridge. USGS Mesozoic locality 30004 (collectors: N.F. Sohl, A.G. Coates, and W.O. Ross, 1971).

Locality 75.—Green Island Formation. Locality immediately south of 69 and about a meter lower stratigraphically. USGS Mesozoic locality 30432 (collectors: N.F. Sohl and E.G. Kauffman, 1971).

Jerusalem Mountain Inlier

Hill (1899) was the first to point out the occurrence of Cretaceous limestone in the vicinity of Jerusalem Mountain, Westmoreland Parish (Text-fig. 2), and Trechmann (1924) was the first to provide an outline of the sequence. Informal names such as "Oyster limestone" and "Titanosarcolites limestone" prevailed in usage until recent years. Jiang and Robinson (1987) have provided the following succession from base to top: Moreland Formation (red conglomerates and shales), Jerusalem Mountain Formation, Masemure Formation (sandstones and shales). The Jerusalem Mountain Formation is divided into a lower Thicket River Limestone Member (="Titanosarcolites limestone") overlain by red shale and some conglomerate that is capped by the Jerusalem Limestone Member (="Oyster limestone"). The thicknesses of the units are not well documented, but the total section appears to be in excess of 200 m.

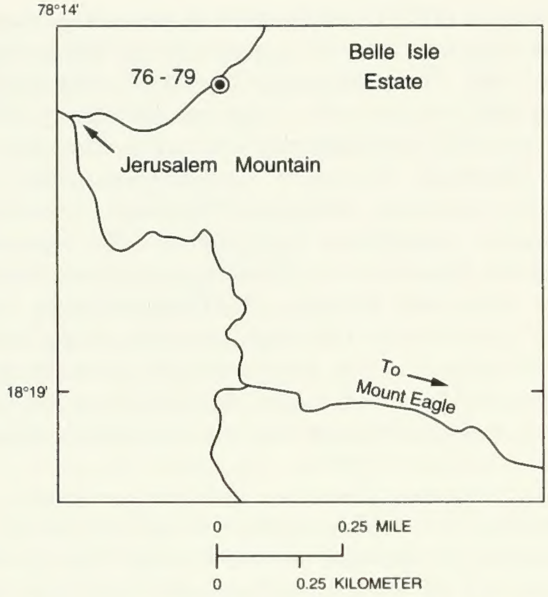
The Jerusalem Limestone Member previously was considered to be the youngest Cretaceous unit in Jamaica, but, as indicated above, it is now known to be overlain by the Masemure Formation. All of the Cretaceous trochaceans collected from the Jerusalem Mountain inlier come from the Thicket River Limestone Member. This member is composed mainly of massive, poorly fossiliferous limestone beds that are interbedded with silty shale and cobbly shale units. The cobbly shales are especially noteworthy for the abundance of the rudist bivalve *Titanosarcolites.* Some beds are dominated by large angular clasts of this bivalve, but other cobbly beds contain abundant, more rounded clasts that are concentrically coated by alga.

Locality 76.—Thicket River Limestone Member of the Jerusalem Mountain Formation. Exposures along the road from Jerusalem Mountain to Belle Isle (Text-fig. 22), northeast of houses that are built on oyster-bearing limestones of the Jerusalem Limestone Member and between 300 and 420 m (airline) northeast of junction with the road from Blairs Hill to Jerusalem Mountain, Hanover Parish. Locality 76 is at lat 18° 19'29" N., long 78°13'14" W. USGS Mesozoic locality 29476 (collectors: N.F. Sohl, E.G. Kauffman, and J.E. Hazel, 1966).

The collection was made from a 1.0-m-thick unit of beige shale that lies 8 m above the base of the section.

Locality 77.—Thicket River Limestone Member of the Jerusalem Mountain Formation. Locality same as for 76, but from a rubbly limestone immediately below USGS Mesozoic locality 29476. USGS Mesozoic locality 29473 (collectors: N.F. Sohl, E.G. Kauffman, and J.E. Hazel, 1966).

Locality 78.—Thicket River Limestone Member of the Jerusalem Mountain Formation. Locality same as for 76, but from a shale immediately above USGS Mesozoic locality 29476. USGS Mesozoic locality 29474 (collectors: N.F. Sohl and E.G. Kauffman, 1966). No fossils from locality 78 are described in this report.



Text-figure 22.—Collection localities 76–79, Jerusalem Mountain inlier, Hanover Parish, Jamaica. Base from land survey sheet 13B, Survey Department of Jamaica.

Locality 79.—Thicket River Limestone Member of the Jerusalem Mountain Formation. Locality same as for 76, but from a rubbly shale about 4.5 m higher in the section than USGS Mesozoic locality 29476. USGS Mesozoic locality 29480 (collectors: N.F. Sohl and E.G. Kauffman, 1966).

SYSTEMATIC PALEONTOLOGY

Introduction

The fact that all the species-level taxa described in the following section are proposed as new reflects, in part, the current level of knowledge of the gastropod faunas of the Cretaceous of the Caribbean area. It also parallels the condition among the rudist bivalves and is an indication that, during the latest Cretaceous, a high level of endemism developed among the molluscan fauna in this region.

All the type specimens for the described species are deposited in the collections of the United States National Museum of Natural History in Washington, D.C. The acronym USNMNH is used along with the pertinent specimen number for each type and illustrated specimen. These are recorded both in the text (in "Types" or "Material") in each species description and in the captions of Plates 1–22. Collection localities for each described species are given in a section entitled "Occurrence," which is keyed to the locality numbers 1–79 presented in the "Stratigraphy and Locality Register". A question mark in parentheses after a locality number indicates that, because of preservational or other factors, the specimens found at that locality can only be assigned to the species with doubt.

Systematics

Class **GASTROPODA** Cuvier, 1797

Subclass **STREPTONEURA1** Spengel, 1881

Order **ARCHAEOGASTROPODA** Thiele, 1925

Superfamily **TROCHACEA** Rafinesque, 1815

Family **TURBINIDAE** Rafinesque, 1815

Subfamily **LIOTIINAE** Adams and Adams, 1854

Genus **PSEUDOLIOTINA** Cossmann, 1925

Type species.—By original designation, *Liotia sensuyi* Vidal, 1921.

Diagnosis.—Shell discoidal, spire flat, umbilicus broad and open; whorls biangulate; aperture circular, near radial; final aperture thickened and sometimes flaring.

Discussion.—The type species, *Liotia sensuyi* Vidal, 1921, occurs in Upper Cretaceous (Maastrichtian) deposits of the Lerida District in Spain. *Pseudoliotina mcleani,* described below, from the Maastrichtian of Puerto Rico, is the only other known Cretaceous species. Living forms include the Indo-Pacific species *Liotina discoidea* Reeve, 1843, and *Pseudoliotina springsteeni* McLean, 1988.

Some confusion exists in the literature as to the assignment of *Pseudoliotina.* Subsequent to Cossmann's (1925) proposal of the name and placement in the Liotiidae, Wenz (1938, p. 338) accepted the genus only with question and placed it in the Liotiinae. Keen and Cox (*in* Knight *et al.,* 1960) initially accepted and diagnosed *Pseudoliotina* as a member of the Liotiinae on page I266, but on page I273 placed it in the synonymy of *Cyclostrema* Marryat, 1818, of the Cyclostrematidae. McLean (1987, 1988) and Hickman and McLean (1990) recognized the genus as a valid member of the Liotiinae, the placement accepted herein.

Pseudoliotina mcleani Sohl, new species

Plate 1, figures 2, 3, 6, 7, 8, 11, 12

Diagnosis.—A *Pseudoliotina* having strong cancellate sculpture over upper whorl face and sides and smooth basal whorl slope that terminates at serrate umbilical margin.

Description.—Shell medium to small, discoidal, phaneromphalous. Protoconch incompletely known, small, rounded, apparently less than one full whorl, and lies flush with plane of succeeding whorl. First teloconch whorl with deeply impressed suture, flat upper face, and carinate shoulder; below shoulder, whorl side flat. At about one and one-quarter whorls, spines appear on whorl carination that continue anteriorly as transverse ribs on whorl sides. At beginning of second whorl, transverse ribs appear on upper whorl face and continue over whorl sides, but terminate at basal margin of whorl. Spiral sculpture appears at about same time as transverse ribs and consists of one strong, round-topped cord on upper whorl face, second cord at whorl shoulder, and three cords over whorl sides; lowest spiral cord delimits whorl sides from smooth basal shell slope. Intersection of spiral and tranverse sculpture elements provides rectangular, cancellate pattern; strong, raised, subspinose nodes may develop where transverse ribs override spiral cords.

Base concave, formed by inclined, planar shell surface terminating in nodose umbilical margin; basal surface virtually smooth except for faint transverse undulations and growth lines. Aperture circular, with low prosocline inclination to axis; margins much thickened, coinciding with final transverse rib; medial columellar rim thinner than remainder of peristome; lower columellar and adaxial part of basal rim somewhat flared and may bear faint spiral striations; flaring terminates in short process directed into umbilical cavity; final aperture, round-topped ring protruding slightly beyond surface of flared apertural reinforcement.

Etymology.—The species is named for James H. McLean in recognition of his outstanding contributions to knowledge of the Trochacea.

Measurements.—The two available specimens from the limestones within the El Rayo Formation (locality 14) of southern Puerto Rico measure 7.0 and 7.1 mm in diameter, respectively.

Discussion.—*Pseudoliotina mcleani* is represented in the collections by only two specimens that were recovered from siliceous residues. However, the specimens are complete except for poor preservation of the nuclear whorl. The only notable difference between the specimens is primarily related to the strength of the sculpture elements (compare Pl. 1, figs. 2,8). The presence of striae on the apertural margin, seen in the specimen on Plate 1, figure 3, cannot be detected on the specimen shown in figure 12. These striations are so fine that either slight wear or a minor preservational factor might account for their absence.

Compared to the type species, *Pseudoliotina sensuyi* (Vidal, 1921) (shown in Vidal, 1921, pl. 6, figs. 2 and 3), from the Maastrichtian of Spain, *P. mcleani* possesses a more pronounced cancellate pattern of sculpture, lacks a spiral ridge on the shell base, has a much narrower umbilicus, and is only about one-half the size. *Pseudoliotina springsteeni* McLean, 1988, from the Philippines, is similar to *P. mcleani* in possessing spines along the peripheral carination, but differs in having a wider umbilicus and an adaxially inclined whorl side profile below the peripheral carination, and in details of sculpture.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, limestones of the El Rayo Formation at locality 14 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468033; paratype USNMNH 468034.

Genus **ARENE** Adams and Adams, 1854

Type species.—By subsequent designation (Woodring, 1928), *Turbo cruentata* Mühlfeld, 1824.

Diagnosis.—Shell small to medium size, spire low, phaneromphalous; aperture circular, radial; sculpture of fine transverse lamellae and nodose spiral cords.

Discussion.—Most compendia consider *Arene* to range from the Miocene to the Holocene. The species described below from the Cretaceous of Jamaica possesses three characters that typify the "Informal Group Liotinae + Angarinae" of Hickman and McLean (1990, p. 36): a circular generating curve, scaly transverse sculpture, and near radial aperture. In character of sculpture and general shell form, it so closely approaches several living species of *Arene* that, despite the gap in the fossil record, I have placed the species described below in that genus.

Arene truncatosphaera Sohl, new species

Plate 1, figures 1, 4, 5, 9, 10, 13; Plate 2, figure 4

Diagnosis.—Shell small and apically trucate; whorls of spire with three, strong, raised, rounded and noded, spiral cords situated respectively on upper whorl face, at shoulder, and between shoulder and following suture.

Description.—Shell small, apically truncate, phaneromphalous. Protoconch small, lowly rounded, apparently smooth, about three-quarters of a turn, and depressed below level of succeeding whorl. Initial one and one-quarter teloconch whorl rounded, depressed below level of subsequent whorl, suture linearly incised. At one and one-half turns, upper whorl becomes flattened with angulate shoulder formed by a raised strong spiral cord. Second strong, raised, nodose spiral cord appears on mid-upper whorl surface at beginning of second teloconch whorl. Three spiral cords present on penultimate whorl, with third placed on whorl side below shoulder; upper edge of fourth cord visible at suture; cord interspaces about equal to cord width. Body whorl bears three spiral cords between suture and periphery and three additional cords on rounded lower whorl and base; umbilicus margined by especially broad cord; umbilical wall with two raised, noded, narrow and weak spiral cords; nodes may develop hollowed spinosity at forward end. Transverse sculpture consists of closely spaced, raised, scaley, collabral threads; threads override spiral cords and are sinuous in trend in some interspaces. Final one-quarter of body whorl becomes slightly disjunct. Aperture entire, near circular, and slightly inclined; terminal flare slight.

Etymology.—From the Latin *truncatus,* to shorten by cutting, and *sphaera,* ball; pertaining to the truncately rounded shell.

Measurements.—The largest specimen, a paratype (USNMNH 468039), measures 3.6 mm in height and 4.1 mm in diameter. A smaller paratype (USNMNH 468038) measures 3.0 mm in height and 3.6 mm in diameter. The overall tendency among the available specimens is for height to increase proportionally more than diameter with increased size.

Discussion.—*Arene truncatosphaera* is restricted to Maastrichtian deposits of Jamaica, where it occurs in lagoonal shales, mudstones, and fine- to medium-grained bioclastic sandstone. About 35 specimens, nearly half from the type locality (locality 54), are available for study. Little variation in strength or placement of sculpture elements can be detected among the specimens. The small size of the specimens raises the question of their being immature, but the sequence of growth stages and the tendency for late-stage disjunct coiling suggest that they are mature shells.

The sequential development of sculpture is especially well shown by the specimen figured on Plate 1, figure 10. This figure clearly shows the change from the early round-topped whorls, which are marked only by transverse threads, to later whorls possessing a strong shoulder and noded spiral cords. Details of the scaly, closely spaced, thin and flat-topped transverse threads are shown in figure 4 on Plate 2. The rectangular form of the spiral nodes is also well shown in the same figure, but the tendency for development of subspines at the adaperatural node edge is better displayed on Plate 1, figure 10.

Several living species show characters similar to those of *Arene truncatosphaera.* Both *A. guttata* McLean, 1970, from the Galapagos Islands, and *A. boucheti* Leal, 1991, from Trinidade Island, are low-spired forms with rounded early whorls marked by transverse threads, and later sculpture of noded, strong, spiral cords. However, both living species have a less trucate apex, are proportionally broader, have more prosoclinely inclined apertures and have minor differences in sculpture.

Occurrence.—Jamaica: Maldon inlier, Shaw Castle Shale, at locality 46; Marchmont inlier, "Titanosarcolites limestone" at localities 52, 53, and 54 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468035; paratypes USNMNH 468036, 468037, 468038, 468039.

LIOTIINAE undetermined

Plate 2, figures 6, 7, 8

Discussion.—The specimen figured on Plate 2, figures 6, 7, and 8, is incomplete but possesses characters that suggest the presence of an undescribed liotiine species in the Cretaceous Caribbean faunas. The specimen is from the upper Campanian beds of the Botijas Limestone Member of the Pozas Formation at locality 4 in Puerto Rico.

The shell is small (5 mm in diameter; 3.3 mm in height), consists of about four and one-half whorls, and has a depressed turbinate form. The whorls of the spire are initially gently inclined below the incised suture and terminate in an angulate shoulder below which the whorl is more steeply inclined. The surface is covered by fine, closely spaced, spiral lirae that are intersected by microscopic, collabral, transverse threads (Pl. 2, fig. 7). Subsequently, a low welt develops adjacent to the suture, the main upper whorl face becomes broadly concave, and the shoulder is formed by an elevated carination, which bears raised nodes at the intersections with the transverse ribs of the whorl sides. Spiral, low cords become prominent over the subsutural welt, and low tranverse cords of variable strength cross the upper whorl face.

The body whorl is flat and slopes steeply between the shoulder and the rounded periphery. The basal surface rounds down to an excavated area that is bounded by a strongly raised and round-topped spiral welt that margins the umbilicus (Pl. 2, fig. 8). Prominent, elevated, sharp-crested, collabral, transverse ribs cover the whorl sides from the shoulder to the excavated area on the base (Pl. 2, figs. 6,8). Fine, closely spaced growth increments are present both on the ribs and in the interspaces. Spiral lirae also cover the whorl sides and base and override the transverse elements. The umbilical wall is smooth but bears a rounded, internal, spiral welt that forms a projection of the inner lip where it terminates at the aperture.

The aperture is incompletely preserved but is round and near radial. The parietal and columellar lips are thickened and are flared terminally, with the lower part reflected back over part of the umbilicus (Pl. 2, fig. 8). There is an indication that the outer lip is flared, and a thick projection seems to occur at the junction of the whorl shoulder with the aperture.

Final assignment of this taxon must await further material that better preserves the full apertural characters. Of the accepted liotiines, it perhaps compares most closely to certain species of *Macarene* Hertlein and Strong, 1951, in its depressed turbinate form, and basal slope and umbilical features (see fig. 8d in Hickman and McLean, 1990).

Occurrence.—Puerto Rico: Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation at locality 4.

Age.—Late Campanian.

Material.—Figured specimen USNMNH 468044.

Subfamily **ANGARIINAE** Thiele, 1924

Hickman and McLean (1990) justified acceptance of Angariinae over the older name Delphinulinae Stoliczka, 1868, because of its more common usage and argued for conservation under Article 40b of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature, 1985). Acceptance of Angariinae also conveniently circumvents the potential of further confusion because *Delphinula* Lamarck, 1804, is an objective synonym of *Angaria* Röding, 1798.

Following Hickman and McLean (1990), Nododelphinulidae Cox, 1960, is included within the Angariinae herein. So construed, the subfamily has its earliest representatives in the Upper Triassic.

Genus **NODODELPHINULA** Cossmann, 1916[a]

Type species.—By original designation, *Delphinula buckmani* Morris and Lycett, 1851.

Diagnosis.—Shell turbiniform, phaneromphalous; body whorl usually biangulate. Umbilical margin carinate and commonly noded. Aperture entire, near radial, subcircular, and commonly with anteriorly thickened, columellar lip.

Discussion.—Cossmann (1916a) included 19 previously described Middle Jurassic through Cretaceous species within *Nododelphinula.* Many of these are poorly understood species, known only from the original, commonly short, descriptions and poor figures. A few additional species (*N. galeotti* Alencaster de Cserna, 1956; *N. bellisculptata* Jaworski, 1936; *N. elegans* Nagao, 1934) have been proposed, and others have been reassigned to *Coelobolma* Cossmann, 1918, or *Palangaria* Mongin, 1985.

Among the remaining species Cossmann assigned to *Nododelphinula,* pattern of sculpture varies greatly, ranging from those having mainly spiral cords to others in which broad transverse ribs are present. Similarly, the development of bicarinate whorls is variable. The genus needs reevaluation, but the whorl profile and umbilical and apertural characters do circumscribe a small distinctive group of species similar to *N. buckmani* (Morris and Lycett, 1851) and *N. hudlestoni* Cossmann, 1916[a].

Nododelphinula trechmanni Sohl, new species
Plate 2, figures 1, 2, 3, 5

Diagnosis.—Shell small, turbiniform; whorl shoulder and umbilical margin angulate and noded.

Description.—Shell small and turbiniform; protoconch incompletely known, consists of about three-quarters of rounded whorl. First teloconch whorl well rounded; suture deeply impressed. Flat subsutural ramp and shoulder angulation develops on second teloconch whorl; body whorl slightly convex below shoulder, subangulate at junction with steeply inclined basal slope. Umbilicus deep, broad, about one-half total shell diameter; umbilical margin angulate and noded; umbilical wall with slightly concave slope. Sculpture of first teloconch whorl poorly known, but seems faintly reticulate; spiral threads appear early on second whorl followed by faint transverse cords; spirals strengthen with growth, forming raised cord at shoulder and well-separated cords near mid-whorl and basal subangulation; spirals of basal slope closely spaced and finer than those on whorl sides; spirals faint on umbilical wall. Transverse sculpture on spire of fine, closely spaced, continuous, low cords; body whorl with widely spaced, broad transverse ribs between suture and periphery; nodes on ribs at shoulder and on first spiral of whorl side; transverse sculpture weak below periphery but strengthens over basal slope where ribs develop raised nodes at umbilical margin; ribs diminish in strength over umbilical wall. Aperture incompletely known; outer lip angulate at shoulder; inner lip well rounded, with an angulation at intersection of umbilical rib.

Etymology.—Named for C.T. Trechmann in recognition of his many contributions to the knowledge of the Cretaceous rocks of Jamaica.

Measurements.—The largest specimen, the holotype (USNMNH 468040), measures 2.5 mm in diameter and 2.1 mm in height.

Discussion.—This species is known from only four specimens from the type locality (locality 65) in shales of the "Titanosarcolites limestone" of the Marchmont inlier in Jamaica. In form, this species is similar to the type species *Nododelphinula buckmani* (Morris and Lycett, 1851), as figured by Cossmann (1916a), but has wider spaced and stronger spiral sculpture on the whorl sides and a proportionally broader umbilicus. *Turbo guerangeri* d'Orbigny, 1842, from the Cenomanian of France, and its allies also have less strong spiral sculpture and a narrower umbilicus. *Nododelphinula hiraigensis* Kase, 1984, from the Aptian of Japan, is similar in shell outline and the tendency for the transverse ribs or costae to diminish in strength over the whorl sides, but differs in having stronger spiral sculpture and a more clearly defined bicarination of the body whorl.

Occurrence.—Jamaica: Marchmont inlier, "Titanosarcolites limestone" at locality 65 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468040; paratypes USNMNH 468041, 468042, 468043.

Nododelphinula? nudula Sohl, new species
Plate 3, figures 1–5

Diagnosis.—Shell, low-spired, turbiniform; body whorl bicarinate, lacking pronounced sculpture but having noded umbilical rim.

Description.—Shell small, depressed turbiniform, about three and one-half whorls, broadly phaneromphalous. Protoconch unknown; scar small. Initial whorl rounded and lies in plane of second whorl; subsequent whorls have flat subsutural ramp bounded by carinate shoulder; body concave over whorl side between shoulder and basal carination. Whorl base flat, steeply inclined. Sculpture restricted to row of faint, low, subsutural nodes. Umbilicus broad, margined by strongly noded, sharp carination; umbilical wall with single low, spiral cord that terminates in slight thickening at upper edge of columellar lip. Aperture entire, circular, slightly inclined to axis; final aperture slightly flared, thickened at junctions of inner and outer lips and columellar and basal lips.

Etymology.—From the Latin *nudulus,* diminutive of *nudus* or naked; pertaining to the small size and lack of sculpture that are characteristic of the species.

Measurements.—The holotype (USNMNH 468045), from locality 14 in Maastrichtian limestone of the El Rayo Formation, Puerto Rico, measures 3.9 mm in height and 4.1 mm in diameter.

Discussion.—Only the three type specimens of *Nododelphinula*? *nudula* are available for study, but the depressed spire, bicarinate whorls, generally smooth surface, and other features are so distinctive as to merit formal description. Assignment to *Nododelphinula* is questioned because the depressed spire and lack of sculpture are atypical for the genus. However, the bicarinate whorls and the apertural and umbilical features fall within the scope of that taxon. The lack of any pronounced spinose spiral cording, in addition to the presence of bicarinate angulations, separates this species from those of *Metriomphalus.*

Hickman and McLean (1990, p. 59) have emphasized that a number of small bicarinate shells described as angariines or trochiines actually represent immature Turbininae. *N.*? *nudula* not only is larger than such immature forms, but it has an initial rounded whorl, and only the later whorls are bicarinate; for these reasons, it is judged mature.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, limestone within the El Rayo Formation at locality 14 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468045; paratypes USNMNH 468046, 468047.

Genus **ANGARIA** Röding, 1798

Type species.—By subsequent designation (Fischer, 1875), *Turbo delphinus* Linné, 1758.

Discussion.—A large number of Jurassic and Cretaceous species have been described and assigned to *Delphinula* Lamarck, 1804, a synonym of *Angaria.* A fair number of these have subsequently been assigned to other angariine taxa or to taxa outside the subfamily. Cossmann (1916a) listed a number of such species, but others have not been assessed since their proposal, and reappraisal is needed of all the remaining Mesozoic species.

Angaria? sp.
Plate 3, figures 6–8

Discussion.—The specimen illustrated in figures 6–8 on Plate 3 is one of five individuals from locality 11 that show features suggestive of *Angaria,* but they are too incompletely preserved to merit formal description.

The shells are moderately small, the largest being 5.5 mm in height and having an estimated diameter of nearly 10 mm. The spire is low in profile, with the earliest whorl slightly depressed below to slightly elevated relative to succeeding whorls. The earliest whorls are flat topped with a carinate shoulder and deeply incised suture. By the third whorl, the shoulder is lost, and the subsutural profile becomes rounded, terminating in a strong, flangelike, spiral, peripheral keel (Pl. 3, fig. 7).

The peripheral keel overhangs the succeeding whorl and bears subspinose projections. Between the suture and peripheral keel, the surface is marked by a subsutural, spiral row of nodes, followed by seven or eight spiral lirae, some of which may become noded. Low, obscure, transverse welts may also occur over the upper whorl, and growth lines become prominent on the upper face of the keel. Below the peripheral keel, the body whorl is well rounded. On small shells, this surface is covered by closely spaced, fine, spiral cords and, near the umbilicus, by transverse costae (Pl. 3, fig. 8). On larger shells, one or more of the fine, spiral cords increase in strength to form nodose or muricate, spiral costae. The umbilicus is broad, is margined by a raised, nodose, spiral cord, and bears three lesser nodose cords on its wall. None of the available specimens retain a full aperture, but it is nearly circular, and the margin is thickened at the position of the peripheral keel.

No Jurassic species seem to compare very closely to this species in form. Among Cretaceous species, *Delphinula chouberti* Collignon, 1972, from the lower Albian of Morocco, *Astraea* (*Delphinula*) *guerini* Bataller, 1945, from the Santonian of Spain, and *Angaria* (*Angaria*) *gwynae* Allison, 1955, from the Albian(?) of Baja California, Mexico, have a similar outline and peripheral carination. Bataller's species also has similar umbilical characters but differs mainly in lacking a flangelike keel and in having strong transverse welts or ribs and may be better placed in *Nummocalcar. D. chouberti* has a flangelike peripheral keel and a subsutural row of nodes, but it has a distinctive pustulose spiral sculpture pattern over the upper part of the whorl sides and lacks the strong, noded cord at the umbilical margin. *Angaria gwynae* differs in having a proportionally higher spire and coarse spiral cords that cover the upper whorl surface. Zekeli (1852) described four species (*Delphinula muricata, D. radiata, D. aculeata,* and *D. acuta*), from the Upper Cretaceous Gosau Beds of Austria, that have a similar low-spired, peripherally keeled profile. All of the above species are poorly known, with apertural and umbilical features obscure, but they may belong in either *Angaria* or *Nummocalcar*.

The general form and characters of *Angaria*? sp. are more commonly displayed by Tertiary species such as *Delphinula helvetica* Cossmann and Peyrot, 1916, or *D. gymna* Cossmann and Pissaro, 1910. These species possess a circular and radial aperture, a very low spire, and a serrate peripheral keel, but they differ from *Angaria*? sp. mainly in details of sculpture.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Revés Member of the Pozas Formation at locality 11.

Age.—Maastrichtian.

Material.—Figured specimen USNMNH 468048.

Subfamily **COLLONIINAE** Cossmann, 1916[a]

According to Hickman and McLean (1990), the subfamily Colloniinae includes Collonidae Cossmann in Cossmann and Peyrot, 1916; Bothropomatinae Thiele, 1924; Homalopomatinae Keen, 1960 *in* Knight *et al.* (1960, p. I270); and Petropominae Cox, 1960 *in* Knight *et al.* (1960, p. I268). So constituted, the subfamily ranges from the Lower Cretaceous (Albian) to the Holocene. The earliest known species preserving a definitive associated operculum is *Petropoma peruanum* Gabb, 1877, from Albian deposits of Peru. Assignment by Cossmann (1918, p. 132) of *Turbo*? *michaleti* Cossmann, 1896, from the Aptian of France, to *Boutillieria* Cossmann, 1888, provides an earlier record, but such an allocation of the species needs further confirmation. Cossmann (1918) assigned a number of additional younger Cretaceous species to *Boutillieria*. Kollmann (1982) considered *Boutillieria* a synonym of *Homalopoma* Carpenter, 1864, and discussed several middle Cretaceous species he assigned to the latter.

As stated by Hickman and McLean (1990, p. 47), the taxonomic placement of the fossil species assigned to the Colloniinae needs thorough revision. The reassignment of *Metriomphalus* Cossmann, 1916[a], that is proposed below suggests a Jurassic origin for the Colloniinae, although shells with a definitive operculum in place are not known until the Albian or Cenomanian.

Genus **ANTILLOCOLLONIA** Sohl, new genus

Type species.—*Antillocollonia brujoensis* Sohl, new species.

Diagnosis.—Shell small, turbiniform, whorls smooth, with well-rounded sides; rate of whorl expansion diminishes with growth as rate of translation increases; suture impressed. Aperture entire, circular, near radial, with a slight posterior notch; outer lip smoothly rounded; parietal lip sinused at junction with columellar lip; upper part of columellar lip thickened by an auricle that extends into umbilicus as a round-topped funicular welt; anterior end of columellar lip slightly expanded and subangulate where intersected by carination of umbilical margin. Umbilicus pronounced, margined by a sharply rounded carination; umbilical wall a concavely rounded channel terminating on funicular pillar.

Etymology.—Antillo, from the Antillean Islands; *Collonia,* a genus of trochacean gastropods.

Discussion.—The genus is proposed for *Collonia*-like shells that differ from species of that genus in the lack of strong beading on the umbilical carination and in the presence of an auricular projection high on the columellar lip. The presence of an umbilicus and its distinctive funicle easily separates *Antillocollonia* from other members of the subfamily.

As known, the genus is restricted to the type species from the Campanian and Maastrichtian rocks of Puerto Rico.

Antillocollonia brujoensis Sohl, new species
Plate 3, figures 17–22

Diagnosis.—As for genus.

Description.—Aperture and umbilical features as described for genus. Protoconch unknown; apical angle about 105°, pleural angle 65° to 70°; initial whorls depressed; body whorl a little more than one-half total shell height; whorls with a faint subsutural collar, well

Table 10.—Measurements of specimens of *Antillocollonia brujoensis* from the type locality (locality 17) in the basal part of the Sabana Grande Formation and limestones within the El Rayo Formation (locality 14) of Puerto Rico.

Specimen	Locality	Height (mm)	Maximum diameter (mm)
Holotype USNMNH 468049	17	6.1	6.0
Paratype USNMNH 468050	17	6.0	5.3
Paratype USNMNH 468051	14	4.7	4.8
Paratype USNMNH 468052	14	4.7	4.5

rounded over sides and base. Sculpture lacking save for very faint low nodes on umbilical carination near junction with aperture.

Etymology.—Named for the settlement of El Brujo, Barrio Llanos Tuna, Municipio de Cabo Rojo, Puerto Rico, near the type locality of the species.

Measurements.—The measurements given in Table 10 are of specimens from the type locality (locality 17) in the basal part of the Sabana Grande Formation and limestones within the El Rayo Formation (locality 14) of Puerto Rico.

Discussion.—This rather rare but distinctive species is restricted to upper Campanian and Maastrichtian rocks of Puerto Rico. As the measurements cited above indicate, height and diameter are nearly equal, but there is an ontogenetic change in growth pattern. In the earliest stages, the whorls are wider than high, but, with continued growth, the rate of translation increases, producing a proportionally narrower shell with a lower pleural angle.

The distinctive features of the aperture and umbilical area are well shown in Plate 3, figures 17–20. The peculiar sinus developed at the transition between the parietal and upper part of the columellar lip is especially clear in figure 18 on Plate 3. A shallow vertical groove that lies inside the aperture along the columellar surface (Pl. 3, fig. 19) may indicate the position of a retracted operculum.

No specimens of *Antillocollonia brujoensis* have been found with an operculum in place. Disassociated opercula, such as that shown on Plate 3, figures 9 and 10, are found in matrix associated with the type specimens and possibly belong to the species. The multispiral inner surface, with long growing edge and pustulose exterior, is reminiscent of Colloninae opercula. The operculum shown on Plate 3, figures 9–10, has a central depression on the exterior surface, but it lacks the conspicuous central pit and tongue-shaped projection that terminates toward the columellar surface that are present in *Collonia.* In this regard, it is similar to *Collonista* Iredale, 1918 (Hickman and McLean, 1990, fig. 19a). However, the connection of this operculum to *Antillocollonia* cannot be proven until a specimen is found in place in the aperture.

Occurrence.—Puerto Rico: San German quadrangle, from a derived limestone block in the base of the Sabana Grande Formation at locality 17 (type locality); Sabana Grande quadrangle, from limestones within the El Rayo Formation at locality 14.

Age.—Late Campanian and Maastrichtian.

Types.—Holotype USNMNH 468049; paratypes USNMNH 468050, 468051, 468052.

Opercula of **COLLONIINAE**

Plate 3, figures 9, 10

Discussion.—Opercula of general Colloniinae type occur in numerous samples in the Upper Cretaceous deposits of Puerto Rico and Jamaica. No specimen of the type shown on plate 3, figures 9 and 10, has been found in place in the aperture of a shell. Most specimens are less than 5 mm in diameter. The inner surface is multispiral, with a long growing edge, and forms a very low cone in profile. The outer face is asymmetrically convex with a subcentral depression and pustulose surface. Most specimens are of this type, but one operculum from locality 14 appears to have narrower whorls, indicating that it expanded more slowly, and may represent a second type.

Opercula are especially common (200+) at locality 11 in the shales of the Revés Member of the Pozas Formation of Puerto Rico. The specimens show wear and commonly are overgrown by algae. Their abundance at this locality appears to be the result of selective concentration by transport.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Revés Member of the Pozas Formation at locality 11; Sabana Grande quadrangle, El Rayo Formation at localities 14 and 15; San German quadrangle, Cotui Limestone at locality 16; Sabana Grande Formation at locality 17. Jamaica: Central inlier, Guinea Corn Formation at locality 43; Maldon inlier, Shaw Castle Shale at locality 46; Marchmont inlier, "Titanosarcolites limestone" at localities 53, 62, and 65; Lucea inlier, Askenish Formation at locality 67; Green Island inlier, Green Island Formation at locality 69.

Material.—Figured specimen USNMNH 468053.

Genus **METRIOMPHALUS** Cossmann, 1916[a]

Type species.—By original designation, *Turbo davoustii* d'Orbigny, 1850.

Diagnosis.—Shell turbiniform, medium size, phaneromphalous; spire initially low to depressed with high rate of whorl expansion followed by increased rate of translation to maturity; generating curve circular; whorls rounded with deeply incised suture, may deviate in growth direction at latest stages. Aperture circular, variably inclined to axis, internally thickened in adult, and may flare at terminus. Umbilicus narrow to moderately wide in early stages, but may become virtually closed by overgrowth of last whorl. Body whorl sculpture dominated by numerous, strongly raised, spiral cords that cover whorl sides, base, and umbilical walls; cords nodose to spinose. Early whorls may develop nodose to spinose peripheral carination. Operculum thick; inner surface a low, multispiral cone with a long growing edge; outer surface convexly raised; pustulose, raised rays radiate from a central pit of petaloid outline.

Discussion.—Cossmann (1916a, pp. 223, 224) listed one Upper Triassic and numerous Jurassic and Cretaceous species as members of *Metriomphalus*. The genus was included in the Nododelphinulidae by Cox (1960), a group subsequently included within the subfamily Angariinae by Hickman and McLean (1990). It is here reassigned to the Colloniinae because of the calcareous character of the operculum that is found in place in several species assigned to *Metriomphalus*.

The type species, *Turbo davoustii*, is from the Bathonian of France. Its validity has been questioned by Fischer (1969, p. 144), who maintained that d'Orbigny's (1850, p. 266) diagnosis was insufficient for recognition. Fischer synonymized the species with the Bathonian species *Turbo hamptonensis* Morris and Lycett, 1851. In proposing the genus, Cossmann (1916a, pl. 10, figs. 6, 7) figured a specimen he assigned to d'Orbigny's species. Delpey (1938, fig. 2) subsequently provided an additional figure. Earlier, Hudleston (1894, p. 360) recognized d'Orbigny's species as occurring in Bathonian deposits in England. The fact that other authors have been able to recognize the type species suggests there is no need to question its validity. Secondly, if, as Fischer suggested, the type species and *T. hamptonensis* are synonyms, then d'Orbigny's name should be maintained because of priority.

Fischer (1969) proposed two subgenera of *Metriomphalus*: *Metriacanthus* and *Planiturbo*. The subgenus *Metriacanthus* differs from the nominate subgenus in details of sculpture. *Planiturbo*, among other distinguishing characters, possesses bicarinate early whorls. Hickman and McLean (1990) emphasized that a juvenile bicarinate shell is typical of the subfamily Turbininae, and, thus, *Planiturbo* may be better placed therein.

The morphologic range of fossil species that Cossmann (1916a, pp. 225–226) included in *Metriomphalus* is so broad that reevaluation of assigned taxa is needed, but that is beyond the scope of this study. Most species possess a number of characters that are reminiscent of the Angariinae: circular generating curve; strong, spinose spiral ribs; flaring of the final apertural margin; and tendency to terminal disjunct coiling. The general shell characters are similar to those in such genera as *Pseudoninella* Sacco, 1896, of the Angariinae. However, as noted above, the presence of a calcareous operculum rules out assignment to that subfamily. In total, the sum of characters suggests assignment to the Colloniinae.

In addition to the Caribbean species described below, two other Cretaceous species of somewhat similar form and having associated opercula are worthy of discussion here. *Calliomphalus (Metriomphalus) hupei* Delpey, 1939, from the Cenomanian of France, is a proportionally higher spired form than the Caribbean species, with wider spaced, nodose, spiral cords and an umbilical chink. Its operculum has a central pit externally and, as figured, seems to have a tonguelike extension suggestive of Colloniinae affinities. *Turbo naumanni* Geinitz, 1874 (includes *Trochus goupilianus* Geinitz, 1874, non d'Orbigny, 1842), from the Cenomanian of Bohemia, has an operculum that is conically multispiral on the internal face; the convex pustulose outer face has a circular central pit. As figured by Weinzettl (1910), the species shows a general similarity to *M. woodringi* (described below) from Puerto Rico.

Other Cretaceous species converge, in sculpture and form, on the Caribbean species, but they are too poorly known to make close comparisons; examples of these similar species follow:

Delphinula sensuyi Bataller, 1949, from the Maastrichtian of Spain;
D. jacobi Basse, 1933, from the Campanian of Madagascar;
Turbo schweinfurthi Fourtau, 1904, from the Maastrichtian of Egypt;
Calliomphalus (Metriomphalus) toucasi Delpey, 1942, from the Santonian of France; and
Turbo renauxianus d'Orbigny, 1842 (see Roman and Mazeran, 1920), from the Turonian of France.

Metriomphalus woodringi Sohl, new species
Plate 4, figures 1–6, 9–17

Diagnosis.—*Metriomphalus* with spinose carinate shoulder on early whorls and 12 to 13 strong, spiral cords on body whorl between suture and umbilical margin.

Description.—Shell as diagnosed for genus. Protoconch small, poorly known; initial whorl and one-half with smooth, broadly convex upper face that is sunken below plane of succeeding whorl; peripheral, flangelike, spine-bearing carination develops at shoulder before beginning of second teloconch whorl and overhangs deep sutural channel. Nodose spiral cords develop sequentially over area between suture and periphery; first cord appears at margin of sutural channel followed later by three more cords that decrease in

Table 11.—Measurements of height (H) and maximum diameter (MD) of specimens of *Metriomphalus woodringi* from locality 14.

Height (mm)	Maximum diameter (mm)	H : MD
2.8	5.7	0.49
3.4	5.8	0.59
4.9	7.6	0.64
6.7	9.9	0.68
8.2	11.0	0.75
10.0	12.6	0.79
10.8	12.8	0.84
11.3	13.3	0.85
11.7	13.0	0.90
12.3	14.1	0.87
12.3	14.5	0.85

strength toward periphery; about five, nodose to subspinose, spiral cords cover rounded whorl surface between periphery and umbilical margin. Umbilicus about one-quarter total shell diameter; walls bear nodose spiral cords. Peripheral carination is lost on third teloconch whorl as translation vector of growth increases and whorl sides become well rounded. Body whorl bears 12 to 13, raised, spiral cords between suture and umbilical margin; adaperturally directed, hollow, spinelike imbrications common on cord crests; faint secondary spiral threads may appear in spiral interspaces.

Etymology.—Named for Wendell P. Woodring in recognition of his many contributions to the geology and molluscan paleontology of the Caribbean region.

Measurements.—Measurements for specimens from locality 14 are given in Table 11.

Discussion.—*Metriomphalus woodringi* is restricted to the type locality in the Maastrichtian limestones of the El Rayo Formation (locality 14) of southern Puerto Rico, where it is common.

The measurements of specimens given above show well the change in growth pattern with increased size. The increase in the ratio of height to diameter reflects the accentuated rate of translation during later stages of growth. The character and sequential development of sculpture on the early whorls of *M. woodringi* are especially well shown on the specimens seen in figures 1, 2, 9, and 11 on Plate 4. As seen in figure 3 on Plate 4, the peripheral spines are adaperturally elevated.

On immature shells, the terminal apertural margin is fluted by the intersection of the strong spiral cords (Pl. 4, fig. 10), but, on older shells (Pl. 4, figs. 14,16,17), the apertural lips are internally thickened to a smoothly rounded margin. The latest stages of growth are accompanied by a downturn of the body whorl near the aperture (Pl. 4, fig. 15) and occasional development of a transverse, varixlike swelling behind the aperture margin. The operculum is retracted behind the aperture margin (Pl. 4, figs. 13,14,17) to a depth at about the position of the external varixlike thickening.

Both *M. horridus* and *M. canabonensis* (described below) are similar to *M. woodringi* in general shell characters, but *horridus* differs in sculpture, in its narrower umbilicus, and in its lack of a spinose periphery on the early whorls, whereas *canabonensis* possesses a medially carinate body whorl.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, El Rayo Formation at locality 14 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468054; paratypes USNMNH 468055, 468056, 468057, 468058, 468059, 468060, 468061, 468062.

Metriomphalus horridus Sohl, new species

Plate 4, figures 7, 8; plate 5, figures 1–20

Diagnosis.—*Metriomphalus* with nonspinose cord at shoulder of early whorls and 8 to 10 strong spiral cords between suture and umbilical margin of body whorl.

Description.—Shell as diagnosed for genus. Initial one and one-half whorl rounded, smooth, and slightly submerged to planar relative to later whorls. Pleural angle decreases with growth commensurate with allometric increase in translation rate during later growth stages. Second whorl becomes flat topped with a spiral liration developing at shoulder and a second spiral forming on the rounded whorl below; within the next one-half whorl, an additional spiral appears above the lower suture, and a fourth spiral soon appears on upper whorl face bordering sutural channel; finally, a fifth spiral is placed between suture and shoulder, and whorl profile becomes rounded. Penultimate whorl bears five strongly raised, spinose, spiral cords and a trace of a sixth cord faintly visible at lower suture; sixth spiral exposed near aperture as body whorl is downturned at final stage. Body whorl bears 8 to 10 spiral cords between suture and umbilical margin. Umbilicus proportionally broad and open in early growth, but reduced to almost a chink at maturity. Aperture margin crenulated in harmony with intersection of spiral cords in early growth; margin internally thickened with well-rounded lips at final stage.

Etymology.—From the Latin *horridus,* bristly or rough.

Measurements.—Measurements for specimens from three localities are given in Table 12.

Discussion.—*Metriomphalus horridus* is easily distinguished from *M. woodringi* by its lack of a flangelike peripheral carination on its early whorls, by the

Table 12.—Measurements of height (H) and maximum diameter (MD) for specimens of *Metriomphalus horridus* from three localities.

Locality	Height (mm)	Maximum diameter (mm)	H:MD
14	4.2	6.8	0.62
14	6.8	9.9	0.69
14	12.8	14.7	0.87
14	22.7	21.6	1.05
11	2.8	3.9	0.72
11	2.9	3.3	0.88
11	2.9	3.4	0.85
11	6.9	7.5	0.92
11	7.5	8.2	0.91
11	7.6	7.6	1.00
44	4.5	5.0	0.90
44	6.2	6.5	0.95

presence of fewer (8 to 10) spiral cords on the body whorl, and by its narrower umbilicus (compare Pl. 4, figs. 7, 8, with Pl. 4, figs. 1, 4). The species is widespread in upper Campanian and Maastrichtian rocks of Puerto Rico and Jamaica.

This species is highly variable in size, with specimens possessing fully adult apertural features ranging between 7 and 23 mm in height. Size difference is also reflected in number of spiral cords present on the body whorl, with smaller specimens having fewer. The five cords present on whorls of the spire, however, are constant regardless of size.

The increase in rate of translation vector during growth is reflected by the trend of greater height relative to maximum diameter shown in the table of measured specimens. The contrast between the early stage aperture and the terminal aperture is well shown by contrasting figures 5 and 8 with figures 1 and 9 on Plate 5. In the earlier stage (Pl. 5, fig. 8), the outer and basal lips are strongly crenulated, reflecting the position of the highly elevated, spiral cords of the body whorl. Subsequently (Pl. 5, fig. 9), the apertural margins thicken, and the apertural rim becomes smoothly circular. Accompanying this stage in development there is also a downturn of the body whorl (Pl. 5, figs. 2, 9) that increases the angle of inclination of the aperture relative to the shell axis. The development of an external varixlike swelling on the terminal part of the body whorl is rarely present.

The operculum of *Metriomphalus horridus* (Pl. 5, figs. 4, 13–18, 20) is very similar to that of *M. woodringi* (Pl. 4, fig. 17). The exterior shelf margining the raised central pad is prominent on the specimen shown on Plate 5, figure 20, but the central pit is obscured by cemented matrix. This pit is shown on other specimens (Pl. 5, figs. 4, 16, 18), but, on these, the margining shelf and sculpture of the external surface are obscured because of specimen wear.

Occurrence of shells.—Puerto Rico: Central Aguirre quadrangle, Coamo Formation at localities 2 and 3; Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation at localities 4 and 7 and Revés Member of the Pozas Formation at localities 9, 10, and 11; Sabana Grande quadrangle, El Rayo Formation at locality 14 (type locality); San German quadrangle, Sabana Grande Formation at localities 17 and 18(?). Jamaica: St. Anns Great River inlier, Windsor Shale at localities 24 and 25 and St. Anns Great River Formation at locality 29(?); Central inlier, Guinea Corn Formation at localities 34, 35(?), 40(?), and 42(?); Sunderland inlier, Stapleton Formation at locality 44; Maldon inlier, Shaw Castle Shale at locality 46; Marchmont inlier, "Titanosarcolites limestone" at localities 50, 51(?), 55, and 58(?); Green Island inlier, Green Island Formation at localities 69, 70, 71, and 73; Jerusalem Mountain inlier, Thicket River Limestone Member of the Jerusalem Mountain Formation at localities 76 and 79(?).

Occurrence of dissociated opercula.—Puerto Rico: Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation at locality 4 and Revés Member of the Pozas Formation at localities 10 and 11; Sabana Grande quadrangle, El Rayo Formation at localities 14 and 15. Jamaica: St. Anns Great River inlier, St. Anns Great River Formation at locality 28; Marchmont inlier, "Titanosarcolites limestone" at localities 51 and 60; Green Island inlier, Green Island Formation at locality 72.

Age.—Late Campanian and Maastrichtian.

Types.—Holotype USNMNH 468063; paratypes USNMNH 468064, 468065, 468066, 468067, 468068 (operculum), 468069 (operculum), 468070 (operculum), 468071 (operculum), 468072 (operculum), 468073 (operculum), 468074, 468101 (operculum).

Metriomphalus canabonensis Sohl, new species
Plate 3, figures 11–16

Diagnosis.—Spire evenly tapering and proportionally low; body having strong, spinose spiral cord at whorl periphery.

Description.—Shell turbiniform, moderately small (<12 mm), consisting of about four whorls. Spire about one-third total shell height; pleural angle 80° to 84°. Protoconch unknown, but scar small and, along with first teloconch whorl, depressed relative to remainder of shell. Spire evenly tapering; early whorls with broadly rounded upper whorl face that becomes increasingly rounded on body whorl; whorl periphery coincides with strong, generally spinose, spiral cord; below periphery, whorl well rounded, but flattening across base to margin of umbilicus. Sculpture dominated by strong spiral cords; five primary, slightly noded, spiral cords of nearly equal spacing and strength occur between suture and periphery; secondary spiral may rarely appear between fourth and fifth primary; peripheral cord very strong, spinose; six to seven nodose to spinose, strong cords occur between periphery and umbilical margin, cords of base stronger than on upper whorl face; additional cords occur on umbilical walls. Transverse sculpture consists of very slightly prosoclinely directed, fine, closely spaced, scaly growth increments; raised, terminally hollowed spines formed on peripheral and basal spiral cords where overriding transverse elements are accentuated. Aperture entire, nearly circular; inner lip well rounded, but expanding out over part of umbilicus.

Etymology.—The species is named for the Río Cañabón, which flows near the type locality in the Barranquitas quadrangle of Puerto Rico.

Measurements.—The best preserved small paratype (USNMNH 468077) measures 7.5 mm in diameter and 6.2 mm in height. The largest specimen, a paratype (USNMNH 468076), measures 12.0 mm in diameter and 9.0 mm in height. For mature specimens, ratios of height to maximum diameter range from 0.75 to 0.88.

Discussion.—This species is known only from localities 9 and 11, within the Revés Member of the Pozas Formation of Puerto Rico, but is represented by numerous specimens (24). All specimens are replaced by calcite, but they are sufficiently well preserved to show differentiation of shell layers, suggesting the presence of an inner nacreous layer. The virtual radial aperture, its circular outline and indication of terminal flaring, and scaly to spinose sculpture are consistent with placement in *Metriomphalus.*

Variation within the specimens studied is obscured, in part, by what appears to be organic, perhaps algal, overgrowth on the spires of many specimens. Variation in relative height of spire is moderate. Some specimens show a tendency toward development of disjunct coiling in the latest growth stages. This tendency is especially pronounced in the specimen figured on Plate 3, figure 16. On that figure, one can see an increase in the translation growth rate of the body whorl. This increase is marked by an accentuated increase in inclination of the suture relative to the shell axis, resulting in the exposure of the spiral cord below the peripheral cord of the penultimate whorl.

Variation in development of spine elevation is partially masked by subsequent wear of specimens, but the specimen shown on Plate 3, figure 14, indicates that spines can become quite raised and strong.

Positioning of the peripheral cord is constant save for the aberrant specimen shown on Plate 3, figure 16. The strongest cord on this specimen has been displaced anteriorly onto the basal slope and is separated from the cords of the upper whorl face by a broad interspace. Despite the shift in position, the number of spiral cords present over the upper whorl face on this specimen is consistent with that on other specimens. The scaly, almost imbricate, nature of the growth increments is also best shown on this specimen (Pl. 3, fig. 16).

When compared to other species of *Metriomphalus,* this species is especially characterized by the strongly developed peripheral spinose cord. Compared to the type or many other Jurassic species, such as *M. cassius* (d'Orbigny, 1853) or *M. hamptonensis* (Morris and Lycett, 1851), *M. canabonensis* has a proportionally lower spire as well as a strong peripheral cord. A few Jurassic species, such as *Turbo bonjouri* Étallon, 1859, and the species Fischer (1969) assigned to his subgenus *Metriacanthus,* possess spinose peripheral cords and a proportionally low spire, but the upper whorl face in all either lacks spiral ornament or has subdued spiral ornament. In addition, these species possess a stairstepped spire profile rather than an evenly tapering outline.

Among Cretaceous species, only *Calliomphalus* (*Metriomphalus*) *toucasi* Delpey, 1942, from the Santonian of Montagne des Cornes, France, possesses a similar accentuation of the peripheral spiral cord, but it differs in having a less evenly tapering and proportionally higher spire and a less rounded inner lip of the aperture.

Most of the other Cretaceous species listed as belonging in *Metriomphalus* by Cossmann (1916a, p. 226) possess proportionally high spires and lack the accentuated peripheral cord. The following Cretaceous species may belong in *Metriomphalus* because they all have sculpture patterns and shell proportions that are similar to those of the Caribbean species, but all lack the strong, spinose peripheral cord and show other minor differences in shape or sculpture:

Delphinula herengerae Bataller, 1949, from the Aptian of Spain;
Trochus ruizi Bataller, 1943, from the Aptian of Spain;
Calliomphalus stropiolatus Collignon, 1972, from the Albian of Morocco;
Nododelphinula bellisculptata Jaworski, 1936, from the Albian and Cenomanian of Colombia;
Delphinula jacobi Basse, 1933, from the Campanian of Madagascar;
Turbo schweinfurthi Fourtau, 1904, from the Maastrichtian of Egypt; and
Delphinula sensuyi Bataller, 1949, from the Maastrichtian of Spain.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Revés Member of the Pozas Formation at localities 9 and 11 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468075; paratypes USNMNH 468076, 468077, 468078, 468079.

Family **TROCHIDAE** Rafinesque, 1815

Subfamily **EUCYCLINAE** Koken, 1897

Tribe **EUCYCLINI** Koken, 1897

Genus **EUCYCLUS** Eudes-Deslongchamps, 1860

Type species.—By original designation, *Eucyclus obeliscus* Eudes-Deslongchamps, 1860.

Discussion.—According to Hickman and McLean (1990), *Eucyclus* ranges from the Triassic to the Oligocene. Cox (1960, p. I306) included the genus as a member of his superfamily Amberleyacea, but McLean (1981) later presented evidence of the trochacean affinities of the genus, a position accepted here.

Eucyclus? sp.

Plate 8, figure 7

Discussion.—One specimen from the Askenish Formation of the Lucea inlier, Hanover Parish, Jamaica, presents a form distinct from the other trochaceans herein described. It is incompletely preserved, however, and lacks details of the aperture; therefore, it is inadequate for unreserved assignment. The specimen is turbiniform with an evenly tapering spire and distinctly impressed suture. The whorls of the spire bear five raised, nodose to spinose, spiral cords between the suture and a subangulate periphery. A sixth, lesser cord having closer spaced nodes appears just above the suture. Below the peripheral cord of the body whorl, the rounded base bears seven, closely spaced, noded, spiral cords that are less strong than the cords above the periphery. Lateral compression of the specimen has destroyed the form of the aperture.

Occurrence.—Jamaica: Lucea inlier, Askenish Formation at locality 66.

Age.—Early Campanian.

Material.—Figured specimen USNMNH 468080.

Tribe **CHILODONTINI** Wenz, 1938

Tribe ranking of this group follows Hickman and McLean (1990), in contrast to the subfamilial ranking of Wenz (1938) and Keen and Cox (*in* Knight *et al.*, 1960, p. I249). As conceived by Cox (*in* Knight *et al.*, 1960, p. I249), all members of the tribe were restricted to Mesozoic strata. McLean (1982, 1984) assigned such genera with extant species as *Euchelus* Philippi, 1847, *Danilia* Brusina, 1865, and *Turcica* A. Adams, 1854, to the Chilodontinae and extended the range of *Agathodonta* Cossmann, 1918, from the Lower Cretaceous to the Holocene. The earliest representatives of the tribe are found in Jurassic rocks. The included genera are united by having the following: inner and outer apertural lips that are inclined to the shell axis and that lie in, or nearly in, the same plane; various forms of apertural dentition; a well-margined parietal callus; and commonly a cancellate sculpture pattern.

Genus **CHILODONTA** Étallon, 1862

Type species.—By subsequent designation (de Loriol, 1887), *C. clathrata* Étallon, 1862.

Diagnosis.—Shell turbiniform to subpupoidal; spire conical with cancellate pattern of sculpture; aperture oblique with thick, commonly expanded, well-defined parietal callus and numerous teeth spaced around the peristome.

Discussion.—In his diagnosis of *Chilodonta*, Cox (*in* Knight *et al.*, 1960, p. I249) stated that the presence of five apertural teeth is a generic characteristic. Presumably, this led him to include *Odontoturbo* de Loriol, 1887, as a subgenus of *Chilodonta*. As indicated in the descriptions of the Caribbean species given below, more than five teeth may be present on specimens that otherwise have all the characteristics of the genus. *Odontoturbo* lacks parietal callus and the cancellate sculpture typical of the Chilodontini and is probably better placed elsewhere.

Cox (*in* Knight *et al.*, 1960) also believed *Chilodonta* to be anomphalous. In the last stages of growth, when the mature aperture is fully formed, the parietal callus covers the umbilicus. During earlier stages of growth, however, the shell is umbilicate (Pl. 6, fig. 2).

As discussed by Sohl (1987, p. 1089), *Chilodonta* occurs as a common element of the Jurassic corallien facies of western Europe. During the Cretaceous, *Chilodonta* achieved wide geographic distribution in the warmer waters of the Tethyan realm coincident with the spread of carbonate-platform conditions (Sohl, 1987, fig. 2). The species described below are among the youngest representatives of the genus and possess the most complex arrangement of apertural teeth. This appears to be the culmination of a Jurassic to Cretaceous trend toward increasing aperture complexity (Text-fig. 4). The individual abundance and distribution of the Caribbean species are reflective of their being one of the most viable groups among the gastropods of the Cretaceous lagoonal assemblages.

Chilodonta obliqua Sohl, new species

Plate 6, figures 1–17

Chilodonta n. sp. Sohl, 1987, fig. 2.

Diagnosis.—Pleural angle near 65° at maturity; whorls of spire with six strong, raised, spiral cords over whorl sides and a weaker spiral that borders anterior suture.

Description.—Moderately small turbiniform shells;

protoconch unknown; teloconch of five to six whorls. Suture weakly impressed and bordered adapically by a weak to pronounced spiral cord. Whorls of spire slightly excavated between suture and first spiral cord, broadly convex over sides; body whorl well rounded over sides and broadly convex over basal slope. Pleural angle of early whorls near 80° but decreases to 60°–70° at latest growth stages. Sculpture of whorl sides cancellate. Transverse sculpture consists of strong raised collabral costae that are arcuately prosocline over whorl sides; costae narrower than interspaces and diminish to fine lirae or growth lines over basal slope; costae number 27 to 30 on early whorls and decrease to 22 to 24 on body whorl; on swollen or weltlike area behind aperture margin of gerontic stage, costae become closely spaced and more highly inclined to shell axis. Six strong, raised, round-topped spiral cords, which are narrower than their interspaces, cover whorl surface between suture and basal periphery; a variably developed seventh cord occurs immediately above suture.

Low spinose projections commonly occur at intersection of spiral cords and transverse costae. Near aperture of gerontic specimens, spiral cords bend sharply downward and become closer spaced as additional cords appear in interspaces. In early growth stages, spiral cords cover base of body whorl but are less strong and more closely spaced than on whorl sides; in gerontic stages, callus evanesces from aperture and covers base and obscures spiral sculpture. Aperture virtually D-shaped in early stages of shell growth with well-rounded, thin, outer lip; lip internally grooved at position of external spiral cords; parietal lip free of callus; columella curved, bearing low medial swelling and second thickening near junction with parietal lip; lower part of columella rounds gradually to basal lip. With growth, apertural margins thicken and about six low nodes appear on interior of outer lip and two thicker ones on the columellar and parietal surfaces; continued growth accompanied by additional thickening of outer lip, forming strong apertural rim, and development of callus that extends out of aperture onto base of body whorl to near basal periphery of whorl where edges of callus are free; callus surface bears numerous, spirally elongate welts, and numerous coarse nodes develop at apertural margins and project into aperture.

At full maturity, outer lip bears ridgelike node near junction with parietal lip followed immediately and anteriorly by two strong, rounded teeth; teeth separated by round-based interspace of width equal to margining teeth; bifid, broad, but less elevated tooth follows at base of outer lip. Single, comparatively narrow tooth projects posteriorly from basal lip. Columella bears single, massive, compound tooth; tooth forms anterior curving plait that bounds siphonlike channel; channel followed posteriorly by low ridge and then by strong raised plait that does not carry out of aperture. Parietal lip carries low, elongate, ridgelike tooth at apertural margin, but has stronger, elongate tooth internally that margins plait on columellar lip forming a posterior channel. Profile trace of outer lip inclined 40° to shell axis on younger shells and increases to about 65° in gerontic stages.

Etymology.—From the Latin *obliquus,* or slanting, referring to the high inclination of the aperture relative to the shell axis.

Measurements.—The largest available specimen measures 14 mm in height and 12.2 mm in diameter and has a fully formed aperture. The smallest specimen in which an adult aperture is apparent measures 8.1 mm in height and 6.2 mm in diameter and did not reach the gerontic stage.

Discussion.—All the larger known specimens of *Chilodonta obliqua* are replaced by silica and occur commonly at locality 14 in limestone of the El Rayo Formation in southern Puerto Rico; specimens from Jamaica are replaced by calcite and are smaller than those from Puerto Rico. Most of the Jamaican specimens represent adult stages of development showing various gerontic stages of denticle formation around the apertural margins. The specimens figured on Plate 6, figures 11–17, are arranged to show the succession of apertural modification and spread of callus over the shell base. Plate 6, figure 4, shows an apertural profile view of a specimen in the beginning stages of development of the weltlike thickening of the outer lip. Plate 6, figures 7, 9, and 10, show specimens that exhibit the advanced stages of the development of this thickening that is accompanied by increase in the inclination of the outer lip to the shell axis and by the interpolation of secondary spiral sculpture. This latter feature is especially well displayed on the incomplete specimen shown on Plate 6, figure 9. According to Hickman and McLean (1990, p. 79), development of a terminal varix, such as found in *Chilodonta obliqua,* is rare among the Trochacea. The increase in inclination of the apertural surface in such living chilodontines as *Granata* effectively converts the shell to a limpetlike outline and is correlated with the ability to cling to a hard substrate. By analogy, such a habit can be reasonably proposed for *Chilodonta obliqua.*

Descriptions and illustrations of all other species of *Chilodonta* that I have examined are based upon mature specimens and fail to indicate the presence of an umbilicus in early stages of development. The specimen of *Chilodonta obliqua* figured on Plate 6, figures 1–3, shows a shell having an open umbilicus at a stage of growth prior to the development of parietal callus and other modifications of the apertural margin. Traces of this feature are also to be seen on broken adult specimens that exhibit a central void in the shell axis.

Chilodonta obliqua differs from all other species in the genus by having a more highly inclined outer lip, more extensive parietal callus, and a greater shell diameter in proportion to height. Although more complex, the basic arrangement of apertural denticles is similar to that in the type species, *C. clathrata* Étallon, 1862, from the Jurassic (Kimmeridgian) of France.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, limestones of the El Rayo Formation at locality 14 (type locality). Jamaica: Maldon inlier, Shaw Castle Shale at locality 46.

Age.—Maastrichtian.

Types.—Holotype USNMNH 421478; paratypes USNMNH 468081, 468082, 468083, 468084, 468085, 468086, 468087, 468088, 468089.

Chilodonta aff. **C. obliqua** Sohl
Plate 7, figures 4–9, 11–13

Discussion.—A number of specimens belonging in *Chilodonta* are present in the collections studied from several Upper Cretaceous formations in both Puerto Rico and Jamaica. They show characters that ally them to *C. obliqua,* but differ most noticeably in having only five instead of six primary spiral costae on the whorls of the spire (Pl. 7, figs. 4–6, 9). One may question whether this difference is sufficient to merit separate specific distinction. Because the nearly 30 specimens in the type lot of *C. obliqua* show no variance in this character, however, it is thought best to separate the two types until more material is available. A new specific or subspecific name is not proposed because none of the specimens preserve a complete aperture, although a reasonable reconstruction can be made based upon the parts of apertures preserved on several specimens.

The spires of specimens assigned to *C.* aff. *C. obliqua* seem narrower in early growth stages with a pleural angle of about 70° compared to 80° on the early whorls of specimens of *Chilodonta obliqua,* but, at maturity, the pleural angles of both species are about the same. The number of spiral ribbons on the whorls of the spire differs between the two forms, but the number of transverse costae (27–28) is similar. The specimen shown on Plate 7, figure 7, from locality 54, is small and distorted because of compression but possesses an arrangement of apertural denticles similar in plan to that of *C. obliqua.*

Because of preservation factors, the early ontogenetic growth stages of *C. obliqua* are unknown. A few specimens of *C.* aff. *C. obliqua* do preserve such features and probably parallel the growth of *obliqua.* As shown on Plate 7, figures 11–13, the protoconch is well rounded, and the initial teloconch whorl sculpture consists of strong, raised, prosoclinely arcuate, transverse costae that are continuous across the rounded whorls. Very fine spiral threads appear in the intercostal areas after about one and one-half whorls. Spiral sculpture subsequently strengthens until the transverse and spiral elements become equal in prominence, creating a cancellate ornament over the whorl sides.

Occurrence.—Puerto Rico: Central Aguirre quadrangle, Coamo Formation at locality 2; Barranquitas quadrangle, Revés Member of the Pozas Formation at locality 11. Jamaica: St. Anns Great River inlier, St. Anns Great River Formation at locality 27; Central inlier, Guinea Corn Formation at localities 40(?) and 43(?); Sunderland inlier, Stapleton Formation at locality 44(?); Maldon inlier, Summerhill Shale at locality 45(?) and Shaw Castle Shale at locality 46; Marchmont inlier, "Titanosarcolites limestone" at localities 54, 60, 61, and 65.

Age.—Middle Campanian to Maastrichtian.

Material.—Figured specimens USNMNH 468090, 468091, 468092, 468093, 468094, 468095, 468096, 468097.

Chilodonta jamaicaensis Sohl, new species
Plate 7, figures 1–3, 10

Diagnosis.—Pleural angle of adult whorls 49° to 50°; whorls of spire with four strong spiral cords.

Description.—Shell small, turbiniform; spire proportionally high, consisting of about five whorls. Protoconch unknown; pleural angle of mature shell about 50°. Whorls of spire round sided; body whorl with periphery broadly rounding down to highly inclined basal slope; near aperture, whorl grows downward (abaxially), weltlike area develops behind aperture, and growth lines become more highly inclined to axis. Sutures impressed. Whorls of spire bear four round-topped, strong, spiral cords between sutures; cords about as wide as interspaces; lower cord may become virtually flat topped ribbon; fifth spiral sometimes faintly visible immediately above anterior suture. Fourth spiral cord forms periphery of body whorl followed anteriorly by four to five strong, raised, spiral cords over basal slope; cords diminish in width anteriorly; near aperture, cords bend down as they cross weltlike thickened area near aperture. Transverse sculpture consists of collabral, prosocline, widely spaced, relatively fine cords that incline about 7° to plane of suture; subspinose nodes form where transverse cords override spiral cords; intersecting sculpture elements form rectangularly cancellate pattern; on body whorl, transverse cords diminish in strength over fourth and fifth spirals but again form prominent, closely spaced nodes on spirals of basal slope.

Aperture highly inclined (60°) to axis; callus extends out of aperture and covers parietal and columellar parts of body whorl base; outer lip thickened within and bearing one strong, raised node near junction with parietal lip; basal lip rounded and bearing two closely spaced nodes near junction with columellar lip; columellar lip with two strong, plaitlike teeth that extend into aperture.

Etymology.—Named for the island of Jamaica.

Measurements.—The most complete specimen measures 7.2 mm in height and 6 mm in diameter. The largest specimen, missing a small part of the apex, is estimated to have had a length of nearly 8 mm.

Discussion.—Only 10 specimens of this species are known, and most come from beds containing the rudist bivalve *Barrettia gigas* in the Green Island inlier of Jamaica. All specimens are incompletely preserved, but in the composite show all shell characters save for the nature of the protoconch and some aspects of the apertural dentition. Some specimens (Pl. 7, fig. 1) tend toward a subpupoidal outline. This form is the result of accentuated downturn of the body whorl near the aperture.

Compared to *Chilodonta obliqua,* this species is more slender relative to height, has fewer spiral cords on the whorls of the spire and base of the body whorl, and has less extensive parietal callus.

In body proportions, *Chilodonta jamaicaensis* is similar to *Trochus marcaisi* d'Orbigny, 1842, as figured by Cossmann (1903), but has fewer and more widely spaced spiral cords, a more expanded parietal callus, and less regularly spaced apertural teeth. Most other Cretaceous species differ in details of sculpture and are proportionally wider relative to height.

Occurrence.—Jamaica: Lucea inlier, Askenish Formation at locality 67; Green Island inlier, Green Island Formation at localities 69, 70, 71 (type locality), and 72.

Age.—Early to late Campanian.

Types.—Holotype USNMNH 468098; paratypes USNMNH 468099, 468100.

Tribe **CALLIOTROPINI** Hickman and McLean, 1990

Genus **PLANOLATERALUS** Sohl, 1960

Type species.—By original designation, *Calliomphalus argenteus* Wade, 1926.

Diagnosis.—Shell trochiform, phaneromphalous; whorls generally flat sided and basally angulate; suture incised. Protoconch less than one whorl and round topped. Transverse riblets of earliest whorls give way to nodose to spinose spirals on later whorls. Aperture subround, inclination low, nacreous within. Umbilicus bounded by strongly noded, spiral cord.

Discussion.—*Planolateralus* was proposed as a subgenus of *Calliomphalus* Cossmann, 1888, and assigned to the Angariinae (Sohl, 1960). However, the difference in early whorl development (see Sohl, 1960, 1964), the basally angulate, flat-sided whorls of the spire, and the sharply defined nodose margin of the proportionally narrower umbilicus of *Planolateralus* are sufficient to distinguish the two at the generic level.

Hickman and McLean (1990) have removed *Calliomphalus* from the subfamily Angariinae and placed it in the subfamily Eucyclinae, tribe Calliotropini, a placement they suggest with reservation for *Planolateralus.* In addition, the Cretaceous species allied to *Calliomphalus americanus* Wade, 1926 (Stephenson, 1941; Sohl, 1960, 1964), need revision because they have features that suggest close affinities to such genera as *Solariella* Wood, 1842, and *Periaulax* Cossmann, 1888.

In Cretaceous deposits, *Planolateralus* is known from the Campanian and Maastrichtian of the Gulf of Mexico and Atlantic Coastal Plains of the United States and from northwestern Europe. These occurrences are mainly in shallow shelfal, terrigenous clastic deposits. The species described below is the first occurrence in the Tethyan Realm. It there occurs, however, not in the shallow-water facies associated with carbonate-platform rudist framework, but in deeper water, shelfal shales that contain inoceramid bivalves. In this aspect of occurrence, it parallels the facies distribution of the Coastal Plain species.

Planolateralus? hanoverensis Sohl, new species
Plate 8, figures 6, 8–12

Diagnosis.—Shell conical; whorls with three primary, coarsely noded, spiral cords above the noded, angulate basal periphery; umbilicus margined by a row of widely spaced, coarse nodes.

Description.—Shell conical, small, consisting of about seven teloconch whorls. Pleural angle of earliest teloconch obtuse, decreasing with growth to 50°–55° at maturity. Protoconch incompletely known, small and round topped. Initial teloconch whorl horizontal to axis between incised suture and sharp shoulder, whorl side vertical below; upper whorl face becomes inclined on second teloconch whorl; shoulder lost on subsequent whorls as sides develop a straight profile descending to an angulate basal periphery.

Transverse riblets dominate early whorl sculpture; riblets are thin over upper whorl face, noded at shoulder, and thicken below on whorl side. Body whorl with three primary, strong, coarsely noded, spiral cords between suture and basal angulation; first and third cords strongest; nodes well raised and rectangular. Basal angulation formed by raised, broad, spiral band that bears strong, axially elongate nodes that may be overridden by fine spiral lines. Base broadly convex and covered by moderately strong, spiral cords; umbilicus about one-fifth width of base and margined by row of strong nodes; nodes continue on umbilical wall as raised ridges.

Aperture incompletely known; subrounded; outer lip slightly prosocline; inner lip smooth, meets basal lip at slightly obtuse angle.

Etymology.—Named for the occurrence of the species in the Lucea inlier of Hanover Parish, Jamaica.

Measurements.—The holotype (USNMNH 468102) measures 4.5 mm in height and 3.7 mm in diameter, and a paratype (USNMNH 468103) measures 1.9 mm in height and 1.7 mm in diameter. The holotype is from shales in the Hanover Group (Askenish Formation) of the Lucea inlier, Hanover Parish, Jamaica. The paratype USNMNH 468103 is from the Windsor Shale of the St. Anns Great River inlier in St. Ann Parish, Jamaica.

Discussion.—*Planolateralus*? *hanoverensis* is represented in the collections under study by 40 specimens from lower Campanian shales of the Lucea and St. Anns Great River inliers of Jamaica. Many of the specimens show some moderate distortion because of compression, whereas others preserve their shape well. Secondary calcite deposition on the interior of the aperture of the specimen shown on Plate 8, figure 10, gives the erroneous impression that the shell is thick.

The change from well-shouldered early whorls to flat-sided later whorls is well shown on the specimen illustrated on Plate 8, figure 11, as is the change from dominantly transverse to spiral sculpture. The same figure also shows well the quadrangular form of the nodes of the spiral ornament.

The species is assigned to *Planolateralus* with question because of the incomplete nature of the aperture as preserved on the available material. The ontogenetic change in whorl profile and sculpture, the conical shape, and the basal angulation, however, are all features common to members of the genus.

Compared to the species described from coeval and younger Cretaceous deposits of the U.S. Gulf of Mexico and Atlantic Coastal Plain (Sohl, 1960, 1964), *P.*? *hanoverensis* is smaller, has proportionally coarser nodose sculpture, and has wider spaced, but stronger, nodes on the umbilical margin.

Occurrence.—Jamaica: St. Anns Great River inlier, Windsor Shales at localities 23, 24, and 26; Lucea inlier, Askenish Formation at localities 66 and 67 (type locality) and Georgia Complex at locality 68.

Age.—Early Campanian.

Types.—Holotype USNMNH 468102; paratypes USNMNH 468103, 468104, 468105.

Subfamily **TROCHINAE** Rafinesque, 1815

Tribe **TROCHINI** Rafinesque, 1815

The genus *Discotectus* Favre, 1913, discussed below, was included in the subfamily Proconulinae by Cox (*in* Keen and Cox, 1960, p. I249), along with a group of other Mesozoic taxa having apically acute, conical shells. Such a grouping has little cohesion, as pointed out by Hickman and McLean (1990), who allocated *Discotectus* and *Dimorphotectus* Cossmann, 1918, to the Trochini and questionably assigned the remainder of the Proconulinae to the Calliostomatinae.

Genus **DISCOTECTUS** Favre, 1913

Type species.—By subsequent designation (Cossmann, 1918), *Trochus massalongoi* Gemmellaro, 1869.

Diagnosis.—Shell small, generally cyrtoconoid, multiwhorled, anomphalous. Outer lip prosocline, inner lip short with strong, generally flat and oblique plait low on columella that extends out of aperture. Sculpture dominantly spiral.

Discussion.—The oldest known *Discotectus* are in Jurassic rocks. Many of the species now assigned to *Discotectus* were originally described as *Tectus* Montfort, 1810, but differ from that genus in having a distinct, strong, oblique, flat columellar plait that emerges from the aperture rather than only a spiral fold or fold-like twist of the columella.

Kase (1984) suggested that *Discotectus* can be split into two subgenera, based mainly on shells that have a flat or concave base, as opposed to those with a convex base. In addition, he suggested that *Tectus* may have been derived from the species group with a convex base (*Discotectus crassus* group). Cossmann (1918) had also come to this conclusion. The columellar fold of *Discotectus* is proportionally large, however, filling over half of the basal part of the aperture of the small shells composing this genus. It is not a columellar fold in the strict sense, but actually a spatulate disc or shelly pad that is equally attached to the basal lip and to the columellar lip. In this regard, the "fold" of *Discotectus* differs from the small fold found on the columella in the large shells of *Tectus*, which never extends far into the aperture, does not fuse with the basal lip, and does not extend in a semicircular pad out of the aperture. It is unlikely that suppression of the fold of *Discotectus* would yield the conventional columellar structure of *Tectus*.

Table 13.—Measurements of three specimens of *Discotectus coquiensis* from locality 2.

Height (mm)	Maximum diameter (mm)	Height of aperture (mm)
7.0	5.5	2.4
7.5	6.5	2.8
8.4	6.4	3.1

During the Cretaceous, species of *Discotectus* achieved circum-Tethyan distribution. In the Western Hemisphere, Sohl (1971, fig. 12) cited the genus as one of the significant associates of a Caribbean Cretaceous tropical biotic province. The specific and morphologic diversity of the Late Cretaceous *Discotectus* in the Antillean region is unmatched in any area of similar size during the Mesozoic.

Discotectus coquiensis Sohl, new species
Plate 8, figures 1–5; plate 9, figures 4, 6–8

Diagnosis.—Shell moderately small (<9 mm), trochiform; whorls of spire with flat sides that bear seven spiral cords; basal periphery rounded.

Description.—Shell small, conispiral, phaneromphalous. Protoconch unknown; pleural angle 51° to 56° Whorls five to six in number, nearly flat sided with faint swelling above impressed suture; basal periphery of body whorl rounding to very gently convex basal surface. Whorls of spire bear seven broad, spiral ribbons separated by narrow interspaces; body whorl with seven to eight spiral ribbons between suture and periphery; spiral lirae cover rounded basal periphery and base of body whorl. Transverse sculpture limited to highly prosocline growth lines over whorl sides; lines inclined about 35° from suture; growth lines become arcuate over basal periphery and base; faint low nodes occasionally develop where growth lines cross spiral elements. Aperture subquadrangular; outer lip thin at edge and highly inclined to shell axis; inner lip arcuate over parietal region, columellar lip short and thick with disclike plication that obliquely extends into aperture and protrudes forward from aperture; behind protruding rim of columellar plication, lower surface rounds down and merges with adaxial part of basal lip.

Etymology.—Named for the village of Coquí, Barrio Aguirre, Municipio de Salinas, Puerto Rico, near the type locality of the species (locality 2, fig. 9).

Measurements.—Measurements from three specimens from locality 2 are given in Table 13.

Discussion.—*Discotectus coquiensis* is known only from its type locality (locality 2) in the Coamo Formation of southern Puerto Rico, where it occurs in abundance. Amount of variation among the available suite of over 200 specimens from the type locality is small. Some of the larger specimens show a tendency to develop a slightly swollen and more rounded basal periphery (Pl. 8, fig. 4). Spiral ribbons of some specimens are low and broad (Pl. 9, fig. 6); ribbons on other specimens are raised and round topped (Pl. 9, fig. 7). On all specimens, however, the number of such elements remains constant on the whorl sides.

Discotectus sp. A (described below), from the El Rayo Formation of Puerto Rico at locality 14, is similar in shape and sculpture, but possesses nine instead of seven spiral cords on the whorl sides, has nodes on the first subsutural cord, and has a more deeply incised suture. *Discotectus barranquitasensis* (described below) is readily distinguished by its noded spiral cords and inflated periphery of the body whorl.

Occurrence.—Puerto Rico: Central Aguirre quadrangle, Coamo Formation at locality 2 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468106; paratypes USNMNH 468107, 468108, 468109, 468110, 468111.

Discotectus sp. A
Plate 9, figures 1–3, 5

Discussion.—About 70 specimens of a distinctive, rather poorly preserved *Discotectus* have been recovered from acidizing the siliceous limestones of the El Rayo Formation at locality 14 in the Sabana Grande quadrangle of Puerto Rico. The silica replacement of the shells is rather granular and, thus, features of sculpture are not sharply preserved, and no specimens preserve the earliest stages of growth. For these reasons, formal description and naming must await better preserved material. The shells are small (<6 mm maximum diameter), conical, with a pleural angle of 55° to 60°. The whorl sides are virtually flat except for a slight swelling corresponding to the position of the first subsutural spiral cord. The suture itself is rather deeply impressed (Pl. 9, fig. 5). Early whorls generally bear only seven spiral cords, but later whorls have nine. These cords are broader than their interspaces and are low lying. The subsutural cord is the strongest and broadest and bears low nodes. The periphery is broadly rounded, and the base is nearly flat and bears fine obscure spiral threads. The outer lip of the aperture is prosocline and strongly inclined to the axis, and the disclike forward edge of the columellar plait extends out of the aperture but is inclined toward the anterior. This plait joins the basal lip below as well as being affixed laterally to the columella.

This species is similar in form to *D. coquiensis* but has more numerous spirals, the subsutural one being noded, and is also proportionally broader.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, El Rayo Formation at locality 14.

Age.—Maastrichtian.

Material.—Figured specimens USNMNH 468112, 468113, 468114, 468115.

Discotectus barranquitasensis Sohl, new species
Plate 10, figures 1–12

Diagnosis.—Shell, small (<7 mm in maximum diameter), conical; body whorl with inflated, well-rounded periphery; first subsutural spiral ribbon strong and bears raised, rectangular nodes.

Description.—Shell small, slightly cyrtoconoid, with broadly rounded, anomphalous base. Protoconch unknown. Pleural angle 35° to 40°; apical angle near 50°. Spire of about seven whorls; suture impressed; below suture whorl, sides almost vertical over upper one-third, becoming rounded below to periphery. Body whorl rounding over basal periphery to broadly convex base. Growth lines prosocline, inclined about 35° from suture.

Sculpture dominantly spiral; spirals consist of raised ribbons broader than their interspaces and bear elevated subrectangular nodes where crossed by prosocline transverse growth increments. First spiral below suture broad, almost weltlike and bears closely spaced nodes; three to four spiral ribbons of lesser width follow anteriorly over nearly vertical whorl surface above rounded peripheral swelling; on spire, rounded periphery bears three prominent noded spiral ribbons. On body whorl, two to three additional ribbons occur over lower surface of rounded periphery; base covered by round-topped, spiral lirae that become wider spaced toward shell axis and beaded where crossed by sinuous, fine growth lines; near aperture, growth line of base may increase in strength to low ruga. Aperture wider than high, subquadrangular; outer lip highly inclined to shell axis, thin at edge, but thickening greatly within where four obscure denticles may appear, two on upper surface and two near junction with sinuous basal lip. Columella thick with disclike plait extending laterally into aperture and forward, out of aperture, as abaxially inclined wafer with edge thickened, rounded, and slightly downturned; base of columellar plait continuous with adaxial portion of basal lip behind lip edge.

Etymology.—Named for the town of Barranquitas, Puerto Rico, which is near the type locality of the species (locality 4, fig. 10).

Measurements.—Measurements of specimens from the Revés Member of the Pozas Formation of Puerto Rico are given in Table 14. All specimens lack a small portion of the apex, and the measurement of height is an estimate.

Table 14.—Measurements of specimens of *Discotectus barranquitasensis* from the Revés Member of the Pozas Formation of Puerto Rico. All specimens lack a small portion of the apex, and the measurement of height is an estimate.

Height (mm)	Maximum diameter (mm)	Height of aperture (mm)
7.3	6.2	2.8
7.6	6.3	2.7
7.0	6.0	2.5
5.7	5.6	2.1
8.3	7.0	3.1
7.6	6.6	2.8

Discussion.—*Discotectus barranquitasensis* is represented in the collections studied by over 400 specimens. The measurements given above reflect the fact that most of the more complete specimens range between 7 and 8 mm in height. Variation in shell proportions is slight. Some specimens having proportionally greater width have been noted, but this variance is usually related to the repair of shell breakage. Some shells show near vertical trend of the whorl sides below the first subsutural spiral ribbon and above the peripheral inflation (Pl. 10, fig. 7), but others possess a more regular conical whorl profile (Pl. 10, fig. 4).

The greatest variation is found in sculpture pattern. The strength of noding on the spiral ribbons varies from specimen to specimen, but such nodes are present on all except the most worn shells. Usually the first spiral ribbon below the suture is the most prominent (Pl. 10, figs. 11 and 12), but some specimens possess a narrow additional spiral cord as the first element.

The form of the columellar plait is especially well shown on Plate 10, figure 8. On this specimen, the downward bend of the plait margin is well displayed. The fusion of the plait and the basal lip is seen on Plate 10, figure 10, as are the denticles inside the aperture. Denticles are rarely seen on the interior of the aperture. The apical view of the specimen shown on Plate 10, figure 9, is typical in showing the poor state of preservation of the initial whorls present on all specimens.

The whorl profile, consisting of a flat upper subsutural area followed by a rounded, and swollen periphery, coupled with the arrangement of the strongly noded spiral ribbons, distinguishes *Discotectus barranquitasensis* from other species. Its closest affinities seem to lie with *D. coralliophilus* Sayn, 1932, from the Barremian of France. The Barremian species shows a tendency to develop a similar rounded swollen whorl periphery, but it is a proportionally higher shell, and the whorls bear fewer spirals. *Trochus (Tectus) sabinus* Parona, 1909, from the Cenomanian of Italy, appears to be a *Discotectus* with an accentuated, but more angulate periphery.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation at localities 4 (type locality), 5, and 7.

Age.—Late Campanian.

Types.—Holotype USNMNH 468116; paratypes USNMNH 468117, 468118, 468119, 468120, 468121, 468122, 468123, 468124, 468125.

Discotectus gelaberti Sohl, new species

Plate 11, figures 7–13

Diagnosis.—Shell conical, whorls of spire with four strongly noded spiral cords on sides and a fifth cord forming periphery of body whorl.

Description.—Shells conical, rather small for genus (< 6 mm in maximum diameter), phaneromphalous, consisting of six to seven flat-sided whorls; suture weakly canaliculate; periphery of whorl sharply rounded, base broadly convex. Protoconch unknown, pleural angle 50° to 55°.

Sculpture dominantly spiral, early whorls with four strongly noded, spiral cords; nodes highly raised, closely spaced, and with apex of nodes having adapertural inclination; upper cord borders suture with spiral interspace somewhat greater than interspaces between subsequent cords; second, third, and fourth cords of equal strength and spacing, with nodes somewhat more pronounced than those on uppermost cord; fifth cord may appear just above abapical suture on penultimate whorl and is narrower than other cords; body whorl with straight sides or may become slightly concave in profile as periphery becomes inflated; periphery sharply rounded down to broadly convex base that bears few obscure spiral lines. Transverse sculpture limited to highly prosocline growth lines, inclined about 30° to suture; growth lines sometimes raised to sharp fine lines in spiral interspaces of whorl sides but obscure on base. Aperture subrhomboidal, wider than high, outer lip highly inclined to shell axis; inner lip short with disclike plait located at base of columellar lip that laterally extends well into aperture; rounded forward margin of plait extends well out of aperture beyond margin of basal lip; base of plait continuous with basal lip inside of aperture.

Etymology.—Named for Pedro A. Gelabert, in recognition of his contributions to the geologic mapping of the Barranquitas area of Puerto Rico.

Measurements.—Measurements of specimens from locality 11 in the Revés Member of the Pozas Formation of Puerto Rico are given in Table 15.

Table 15.—Measurements of specimens of *Discotectus gelaberti* from locality 11 in the Revés Member of the Pozas Formation of Puerto Rico.

Height (mm)	Maximum diameter (mm)	Height of body whorl (mm)
4.6	4.1	1.8
4.9	4.3	2.0
5.2	4.6	2.1

Discussion.—This species is represented in the collections by over 300 specimens, all from the type locality (locality 11) in the Revés Member of the Pozas Formation of Puerto Rico. Variability among specimens of *Discotectus gelaberti* is not great and is primarily noticeable in development of elements of sculpture and inflation of the periphery. Some specimens (Pl. 11, figs. 7, 13) possess a concave profile to the body whorl, whereas others (Pl. 11, fig. 9) maintain a flat whorl profile to maturity. The degree to which the fifth or peripheral spiral cord is visible on the whorls of the spire also varies, but when seen, it is usually present on the latest whorls of the spire.

Compared to other species, *D. gelaberti* differs in the constant possession of the four strongly noded spiral cords on the whorls of the spire. The only other species in which the spiral nodes are of similar strength is *D. scotti* (described below), but that species possesses only three spinose rows of nodes on the whorl sides that are wider spaced, the growth lines are less highly inclined, and, in addition, the shell has a flat to concave base, not one that is broadly rounded and convex.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Revés Member of the Pozas Formation at locality 11 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468126; paratypes USNMNH 468127, 468128, 468129, 468130, 468131.

Discotectus cyrtoconus Sohl, new species

Plate 11, figures 1–6

Diagnosis.—Cyrtoconoid *Discotectus* with two raised, strong, spiral ribbons marking angulate whorl periphery.

Description.—Shell moderately large for genus, cyrtoconoid, phaneromphalous, consisting of about five whorls. Protoconch unknown; pleural angle near 80° on early whorls of spire, decreasing to as little as 40° at maturity. Early whorls flat to gently convex in profile, becoming concave on later whorls as peripheral angulation becomes inflated. Sculpture of early whorls consisting of about five, closely spaced, spiral cords bounded below by stronger cord that lies immediately above anterior suture; additional cords added on later whorls until on body whorl nearly eight

Table 16.—Measurements of specimens of *Discotectus cyrtoconus* from the El Rayo Formation of Puerto Rico at locality 14.

Height (mm)	Maximum diameter (mm)	H:MD	Height of body whorl (mm)
9.7	8.3	1.17	3.6
8.5	7.8	1.09	3.8
8.7	7.6	1.14	3.8
4.3	4.3	1.00	1.5

fine cords present over upper whorl and two, or rarely three, stronger cords placed over subangulate swollen periphery; base covered by fine, rather obscure spiral striae. Growth lines faint, but highly prosocline over whorl sides and nearly direct over whorl base.

Aperture wider than high; outer lip highly prosocline, inclined nearly 70° to axis of coiling; basal lip gently convex over most of extent, becoming more strongly rounded as it merges with columellar lip, adaxial part overlies part of columellar plait but interiorly merges therewith; columellar lip short and anteriorly bearing a strong disclike plait that laterally extends into aperture with its curved, narrow-edged, adaxial margin protruding well out of aperture.

Etymology.—From the Greek *kyrtos,* humped or curved, and *konos,* cone; referring to the cyrtoconoid shell outline.

Measurements.—Measurements of specimens from the El Rayo Formation of Puerto Rico at locality 14 are given in Table 16.

Discussion.—This is a rather rare species known only from 12 specimens, all occurring at locality 14 in the El Rayo Formation of southern Puerto Rico. All specimens have been recovered from silicified residues, and none preserves a complete apex. The decrease in pleural angle with advanced growth noted in the description is also reflected in the measurements given above. The smallest measured specimen has a height equal to its maximum diameter; in increasingly large specimens, the shell becomes higher than wide.

The development, in later growth stages, of a pronounced inflated periphery is reminiscent of the similar ontogenetic development of *Discotectus barranquitasensis,* but *D. cyrtoconus* is easily distinguished by the presence of the strong peripheral cords and the lack of nodes on the fine spirals of the upper whorl surface.

Outside the Caribbean area, *D. crassus* (Nagao, 1934), as figured by Kase (1984), has a somewhat similar shell profile but differs in its coarsely noded spiral sculpture and proportionally higher aperture. *Trochus (Tectus) sabinus* Parona, 1909, from the Cenomanian of Monte D'Ocre, Italy, belongs in the genus *Discotectus.* Its ontogenetic development, form of periphery, and general sculpture pattern are similar to those of *D. cyrtoconus.* However, the columellar plait is proportionally shorter, it does not extend out of the aperture to the same degree, and there appears to be only one strong cord, instead of two, at the peripheral angulation.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, El Rayo Formation at locality 14 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468132; paratypes USNMNH 468133, 468134.

Discotectus scotti Sohl, new species
Plate 12, figures 1–8

Diagnosis.—Medium-sized, conical *Discotectus* on which flat-sided whorls bear three strongly noded spirals above followed anteriorly by a non-noded raised spiral cord at the peripheral angulation.

Description.—Shell conical, consisting of about seven to eight, flat-sided whorls; sutures slightly incised; periphery angulate, base nearly flat to centrally concave, phaneromphalous. Protoconch unknown. Pleural angle 48° to 52°. Sculpture dominantly spiral, consisting of four raised, spiral cords; widths of spiral cords equal to or narrower than their interspaces; first cord borders posterior suture and, like two following cords, is strongly spinose; spines tend to be spirally elongate; fourth spiral cord forms angulate periphery, base devoid of spiral ornament. Growth lines faint and prosocline and highly inclined to axis. Aperture much wider than high; outer lip profile highly inclined to axis, rounding sharply to basal lip; basal lip slightly convex, rounding adaxially into columellar plait; columellar lip short and bearing disclike plait at base; rounded plait margin extends laterally into aperture and also forward out of aperture.

Etymology.—This species is named for R.W. Scott, in recognition of his contributions to the Cretaceous molluscan paleontology of the Gulf of Mexico region.

Measurements.—Measurements of specimens from Puerto Rico at localities 14 and 17 are given in Table 17. All of these specimens lack a small portion of the apex, and the height measurements are estimates. Height is approximately equal to diameter in these specimens.

Discussion.—All available specimens are preserved as siliceous replacements, and, as can be seen on the illustrations (Pl. 12, figs. 1–8), siliceous gangue obscures some of the fine details of sculpture on the spires of most specimens.

The specimens here included in *Discotectus scotti* are united in having three noded to spinose spiral cords

Table 17.—Measurements of specimens of *Discotectus scotti* from Puerto Rico at localities 14 and 17. All of the specimens measured lack a small portion of the apex, and the height measurements are estimates. Height is approximately equal to diameter in these specimens.

Height (mm)	Maximum diameter (mm)	Height of body whorl (mm)
6.2	6.2	1.7
4.5	4.5	1.4
9.0	?	2.3
6.2	5.8	1.9

on the upper part of the whorl followed by a nonnoded cord marking the peripheral angulation. Although other species, such as *Trochus texanus* Römer, 1888 (see Stanton, 1947, pl. 48, fig. 5), have a similar shell form, none possess the sculpture characters of this species.

Some differences occur between the specimens from the two known localities of occurrence. Those from locality 17, in the San German quadrangle of Puerto Rico, are from the stratigraphically lower position (pre-*Barrettia gigas* Range Zone) and are slightly higher than wide and possess spirally elongate, round-topped spines upon the spiral cords (Pl. 12, figs. 1, 7). The specimens from the *Titanosarcolites*-bearing levels at locality 14 differ in having heights equal to diameters and bear raised, rounded nodes instead of spines upon the spiral cords (Pl. 12, figs. 5, 6, 8). These differences may merit taxonomic separation as chronosubspecies, but the number of specimens, known from only two localities, is insufficient to make such a determination.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, El Rayo Formation at locality 14; San German quadrangle, Sabana Grande Formation at locality 17 (type locality).

Age.—Middle Campanian to Maastrichtian.

Types.—Holotype USNMNH 468135; paratypes USNMNH 468136, 468137, 468138, 468139.

Discotectus crebrinodosus Sohl, new species
Plate 12, figures 9–12

Diagnosis.—Whorls bearing seven to eight closely spaced, noded spiral cords. Upper cord broadest with arcuate prosocline crest on closely spaced nodes. Base of body whorl concave.

Description.—Small, multiwhorled, cyrtoconoid shell. Protoconch unknown; pleural angle 60° to 65°. Whorls of spire gently convex, basal periphery rounded; suture impressed; periphery becomes inflated and sharply rounded on body whorl; below periphery, base of whorl rounds down to concavely flat basal slope. Spiral sculpture dominant and consists of, usually, seven noded spiral cords separated by very narrow interspaces; subsutural cord broadest; subsequent cords nearly equal in width; nodes axially elongated, tend to be arcuately and subangularly crested on subsutural cord but more rounded on lower cords; nodes of succeeding cords appear collabrally aligned across whorl face; generally obscure, fine, spiral lirae cover base of whorl. Aperture incompletely known; outer lip strongly prosocline, short columella bears an oblique disclike fold low on lip.

Etymology.—From the Latin *creber,* close, numerous, and *nodosus,* knotty or noded.

Discussion.—*Discotectus crebrinodosus* is known only from 11 specimens that occur at localities 69 and 72, in the *Barrettia gigas*-bearing limestones (Green Island Formation) of the Green Island inlier of Jamaica. All specimens are incomplete, missing either some part of the spire or a part of the aperture. All specimens are small, less than an estimated 6 mm in height, and some have been distorted by compression. Regardless of these drawbacks, the available material represents a distinctive species.

I am unaware of any other Caribbean or world Cretaceous species of *Discotectus* that possesses similar prosocline, elongate nodes on the spiral elements of sculpture (Pl. 12, figs. 10, 11). This species also possesses a concave basal surface, but none of the species listed by Kase (1984, p. 66) as characteristic of his *D. massalongoi* group, characterized by a concave or flat shell base, is similarly sculptured. *Discotectus zansi* (described below), from a higher stratigraphic position in the St. Anns Great River inlier, is another species having an excavated base and collabrally arranged spiral nodes. It differs in its proportionally higher spire and, more importantly, in having a larger number of spiral cords, in the nodes being narrower, and in having fine, raised, growth lines that are equally prominent in the spiral interspaces as on the nodes.

Occurrence.—Jamaica: Green Island inlier, Green Island Formation at localities 69 and 72 (type locality).

Age.—Late Campanian.

Types.—Holotype USNMNH 468140; paratypes USNMNH 468141, 468142, 468143.

Discotectus zansi Sohl, new species
Plate 13, figures 1–10

Diagnosis.—Spire cyrtoconoid; body whorl with inflated periphery; whorls sculptured by 8 to 11 primary and secondary spiral cords; cords collabrally beaded by fine, raised growth lines.

Description.—Shells cyrtoconoid in early stages; body whorl develops vertical to slightly convex upper profile expanding anteriorly to a rounded periphery;

Table 18.—Measurements of specimens of *Discotectus zansi* from the type locality (locality 27) in the St. Anns Great River Formation of the St. Anns Great River inlier, Jamaica.

Height (mm)	Maximum diameter (mm)	Height of body whorl (mm)
6.2	5.1	2.8
6.6	5.3	2.6
6.8	5.5	3.0
4.7	4.3	2.3

base rounded marginally, becoming concave toward axis. Protoconch unknown. Apical angle 56° to 62°; pleural angle 35° to 40°. Whorls of spire bear eight or nine primary, rounded spiral cords; cords broader than interspaces; subsutural cord strongest, weaker secondary cords may appear in spiral interspaces; base with mixture of fine spiral cords and lirae. Growth lines prosocline, forming fine raised ridges in spiral interspaces, but raised to collabrally elongated nodes where they override spiral cords; traces of growth lines sigmoidal as they trend from spiral interspace over spiral cord and into next interspace; near aperture body, whorl surface may bear discontinuous, raised collabral welts; spiral cords subdued or lost over surface of welts. Aperture with outer lip inclined nearly 35° to axis; columellar lip short and bearing typical *Discotectus* plait.

Etymology.—Named for V.A. Zans, former Director of the Geological Survey of Jamaica and the first geologist to provide details of the stratigraphic sequence of the St. Anns Great River Cretaceous inlier.

Measurements.—Measurements of specimens from the type locality (locality 27) in the St. Anns Great River Formation of the St. Anns Great River inlier, Jamaica are given in Table 18.

Discussion.—*Discotectus zansi* is known only from the type locality in the St. Anns Great River Formation of the St. Anns Great River inlier, Jamaica. Considerable variability in form and sculpture can be noted among the more than 150 specimens available for study (compare Pl. 13, figs. 3 and 5), but all show a constant ontogenetic pattern of decrease in width proportional to height through later growth stages. Consistency is also expressed in the subsutural spiral cord always being the strongest, but the total number of cords present on the whorls of the spire may range from 8 to 11. The presence or absence of secondary spiral cords varies from specimen to specimen, but, most commonly, a secondary spiral is present between the subsutural cord and the second primary cord (Pl. 13, fig. 10).

The two extremes of shell outline are well exemplified by comparing figures 3 and 5 on Plate 13. Figures 3 and 6 exemplify those specimens possessing a proportionally broader outline and a body whorl lacking, or with subdued, development of peripheral swellings near the aperture.

The specimen shown in figure 5 on Plate 13 shows the extreme of the more slender morphotype, in which the collabral swellings of the periphery carry well onto the base (Pl. 13, fig. 4). Figure 9 on Plate 13 is an enlarged view of the body whorl of a paratype that shows the pronounced prosocline inclination of the growth lines relative to the shell axis. The sinuous trace of the growth lines and their accentuation over the crest of the spiral cords are well shown on the specimen shown in figures 7, 8, and 10 on Plate 13. Reduction in strength to loss of spiral cords and development of a direct, instead of wavy, trend in the growth lines are characteristic of areas of collabral swelling in later growth stages and are shown on the specimens figured on Plate 13, figures 5 and 9.

Discotectus zansi is similar to several other species in the development of a swollen and rounded periphery on the body whorl. In this regard, and in having the subsutural spiral cord the strongest, it is similar to both *D. barranquitasensis* (described above) and *D. marchmontensis* (described below), but in neither of these species is there a development of collabral peripheral swellings. In addition to other differences in sculpture, these other species lack the strong development of prominent and sinuous growth lines.

Occurrence.—Jamaica: St. Anns Great River inlier, St. Anns Great River Formation at locality 27 (type locality).

Age.—Late Campanian.

Types.—Holotype USNMNH 468144; paratypes USNMNH 468145, 468146, 468147, 468148, 468149, 468150.

Discotectus marchmontensis Sohl, new species
Plate 14, figures 1–8; plate 17, figure 11

Diagnosis.—Shell moderately small, conical, with flat-sided whorls that bear six to seven spiral cords.

Description.—Shell moderately small, conical, consisting of about six whorls. Spire evenly tapering; pleural angle 55° to 60°; protoconch poorly known, appears to consist of about one small rounded whorl; first two teloconch whorls rounded and transversely ribbed; later whorls flat sided and spirally sculptured; periphery sharply rounded; base broadly convex, but slightly excavated adjacent to pillar. Body and penultimate whorls bear six to seven spiral cords; upper three cords stronger than lower cords and bear rectangular nodes; nodes present, but poorly defined on lower cords. Prosoclinely inclined growth lines variably developed but usually faint. Shell base covered

Table 19.—Measurements for three specimens of *Discotectus marchmontensis*.

Locality	Height (mm)	Maximum diameter (mm)	Height of body whorl (mm)
52	4.4	4.0	2.0
52	5.3	4.8	2.1
43	4.6	4.1	2.0

by spiral cords that become stronger toward pillar; cords crossed by irregularly developed transverse swellings.

Aperture somewhat wider than high; outer lip prosoclinely inclined, thin at edge, thickening interiorly. Columella rounded above and forming round-bottomed excavation at junction with parietal surface; callus may evanesce onto basal slope and be well margined; strongly inclined plait occurs low on columella and extends diagonally into aperture, disclike plait thins at edge into aperture and extends out of aperture and overhangs basal lip; channel below plait continuous between columellar lip and basal lip.

Etymology.—Named for the Marchmont inlier, Jamaica.

Measurements.—Measurements for three specimens are given in Table 19. The largest known specimen has a broken apex, measures 6.5 mm in diameter, and has a body whorl 2.4 mm in height.

Discussion.—*Discotectus marchmontensis* is represented in the collections under study by over 100 specimens from *Titanosarcolites*-bearing shales of the Marchmont inlier of Jamaica. The character of the early whorls is poorly known. Generally the apex is corroded, but a few specimens preserve traces of transverse ribs on the immediate post-nuclear whorls (Pl. 14, fig. 8; Pl. 17, fig. 11). The first spiral element, the subsutural cord, appears when the whorls become flat sided.

Discotectus marchmontensis possesses whorl sculpture similar to that of *Denticulabrum duckettsensis*, but the spiral elements of *D. marchmontensis* are closer spaced and usually more numerous. In addition, it differs mainly in lacking both an expanded rounded periphery on the later whorls and the apertural modification of *Denticulabrum*.

Occurrence.—Jamaica: Central inlier, Guinea Corn Formation at locality 43; Maldon inlier, Summerhill Shale at locality 45; Marchmont inlier, "Titanosarcolites limestone" at localities 52 (type locality), 55, 57, 61, 63, and 64.

Age.—Maastrichtian.

Types.—Holotype USNMNH 468151; paratypes USNMNH 468152, 468153, 468154, 468155, 468156, 468157.

Discotectus sp.

Plate 9, figures 1–3, 5

Specimens that may be assigned with confidence to *Discotectus*, but that are otherwise too poorly preserved to assign to a described species, have been found at a number of localities in both Puerto Rico and Jamaica. These specimens serve mainly as a record of the widespread nature of the genus through both the nearshore lagoonal facies and the shelfal shales.

Occurrence.—Puerto Rico: Cayey quadrangle, Cuyón Formation at locality 1; Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation at locality 6 and Revés Member of the Pozas Formation at localities 10 and 12; Sabana Grande quadrangle, El Rayo Formation at locality 15; San German quadrangle, Cotui Limestone at locality 16, El Rayo Formation at localities 18, 20, and 21. Jamaica: Marchmont inlier, "Titanosarcolites limestone" at localities 52 and 60; Lucea inlier, Georgia Complex at locality 68; Jerusalem Mountain inlier, Thicket River Limestone Member of the Jerusalem Mountain Formation at localities 76 and 79.

Age.—Early Campanian to Maastrichtian.

Material.—Examined specimens: USNMNH 468112, 468113, 468114, 468115.

Genus **DENTICULABRUM** Sohl, new genus

Type species.—*Denticulabrum laevigatum* Sohl, new species.

Diagnosis.—Shells small, conical; whorls of spire generally flat sided with subangulate periphery; body whorl with inflated and rounded periphery. Whorls bear strong, usually noded, subsutural cord; medial whorl surface with or without additional spiral cords. Shell base flattened below rounded peripheral slope and bearing spiral striae marginally and several raised and prominent cords near axis. Aperture wider than high with *Discotectus*-like columellar plait, spiral plait on parietal lip, up to five ridges on interior of outer lip, and several ridges on interior of basal lip.

Etymology.—From the Latin *denticulatus*, having small teeth, and *labrum*, lip.

Discussion.—The presence of a disclike plait situated low on the columella and continuous, behind the apertural margin, with the basal lip, suggests that *Denticulabrum* was derived from *Discotectus*. Additional modifications of the aperture of *Denticulabrum*, including a spiral ridge on the parietal surface and multiple ridges on the inner surface of the outer and basal lips, are features to be found in no species of *Discotectus*. A few species, like *Discotectus barranquitasensis*, possess denticles on the inner surface of the outer lip of the aperture, but these are true denticles and never become raised ridges that project well back inside the whorl. In addition, no species of *Discotectus* possesses a similar concentration of raised strong spiral cords on the shell base near the axis.

Various combinations of nodes or teeth-like protuberances upon one or several areas of the apertural margins are present in a number of other genera of the Trochidae. For example, in some species of *Clanculus* Montfort, 1810, the tooth at the base of the columella may prominently protrude into the aperture, and denticles may be present on the outer lip. The character of the columellar tooth is never disclike, however, and the shells have well-rounded whorls and are umbilicate. *Monodonta* Lamarck, 1799, is another common form having a node or strong tooth at the base of the columella and various other teeth on the interior of the outer or basal lip. Like the tooth in *Clanculus,* the columellar tooth of *Monodonta* is not plaitlike, and the denticles are nodelike and not elongate, raised ridges. Similar differences apply to other trochids like *Clanculopsis* Monterosato, 1879, and *Macroclanculus* Cotton and Godfrey, 1934, which have various modifications of their apertures.

Denticulabrum includes two species: *D. laevigatum* and *D. duckettsensis,* both occurring in the higher Upper Cretaceous deposits of Jamaica. Although *Denticulabrum* seems reasonably derived from a *Discotectus* ancestry, no Tertiary descendants are presently known. As discussed previously, *Denticulabrum* is but one example of a trend during the Campanian and Maastrichtian for the appearance of new and commonly more complex morphologies among long-lived, but generally conservative, gastropod stocks in the Late Cretaceous of the Caribbean region.

Denticulabrum laevigatum Sohl, new species

Plate 15, figures 1–9; plate 16, figure 4

Diagnosis.—Small, trochiform shells with flat-sided early whorl profile; body whorl develops expanded, broadly rounded periphery. Subsutural and peripheral spiral cords separated by smooth shell surface on medial part of whorl.

Description.—Shell small, trochiform, phaneromphalous, composed of about six to seven whorls; pleural angle of early whorls near 65°, decreasing to about 55° at maturity. Protoconch poorly known, but with rounded whorl; earliest teloconch with well-rounded whorl; subsequent whorls become flat sided to slightly concave; suture of body whorl impressed and slightly overhung by periphery of preceding whorl; penultimate and body whorl with upper concave profile leading to inflated, subcarinate periphery. Sculpture of earliest whorls poorly known, but on first one and one-half teloconch whorls consists primarily of raised transverse ribs, narrower than their interspaces. Spiral sculpture dominates on later whorls; upper part of whorls with variably developed subsutural spiral cord, which may bear axially elongate rectangular nodes, is followed by smooth medial whorl area and then faint, low, spiral ribbon and cord immediately above suture; ribbon and cord form peripheral subangulation on latter part of spire and body whorl. Shell base covered by fine, widely spaced spiral lirae that become strengthened to three or four raised, closely spaced spiral cords that disappear under callus deposits of aperture. Transverse sculpture limited to prosocline growth lines; lines obscure on whorl sides and inclined 38° to 40° to suture trace; lines more prominent on base, slightly sinuous in trend, and may produce low nodes as they override coarser spiral elements.

Aperture wider than high; inner lip short, parietal surface with thin callus bears one round-topped, spiral ridge that increases in elevation and strength as it trends into aperture; surface concavely excavated between parietal ridge and obliquely inclined disclike plait of lower columellar lip; plait extends laterally into aperture and forward out of aperture over basal lip; base of plait concavely rounded below where it merges with basal lip. Basal lip slightly sinuous, internally bears two strong, raised, round-topped, spiral ridges that extend 4 to 5 mm into shell interior and are placed equidistant between edge of columellar plication and periphery. Outer lip prosocline and sharp, but thickening abruptly within; lip bears four internal ridges that begin behind lip edge; first and broadest and strongest ridge occurs near junction with parietal lip and becomes bidentate at its crest, forming two internal ridges; second spiral ridge strong and round topped, but of lesser strength than first ridge; third and fourth ridges weaker and, although round crested near aperture, become sharp crested internally; fourth ridge positioned near, but above junction of outer and basal lips.

Etymology.—From the Latin *laevigatus,* smooth or slippery, referring to the lack of sculpture on the whorls of the spire below the subsutural cord.

Measurements.—Measurements for six specimens are given in Table 20.

Discussion.—*Denticulabrum laevigatum* is represented in the collections by over 300 specimens from various Upper Cretaceous localities in Jamaica. Only a modest amount of variation in shape or sculpture is present among the available material. On some specimens (Pl. 15, fig. 3), there is only a barely discernible subsutural spiral swelling, whereas, on others, a well-defined noded ribbon is present (Pl. 15, fig. 4). Similarly, the strength of noding upon this spiral ribbon

Table 20.—Measurements for six specimens of *Denticulabrum laevigatum*.

Locality	Height (mm)	Maximum diameter (mm)	Height of body whorl (mm)
59	6.4	6.5	2.7
61	5.6	5.9	2.4
59	4.3	4.7	1.9
64	6.5	7.0	2.6
64	4.3	5.0	1.8
58	4.1	3.9	1.5

Table 21.—Measurements for six specimens of *Denticulabrum duckettsensis*.

Locality	Height (mm)	Maximum diameter (mm)	H:MD
58	4.5	5.3	0.85
51	4.8	5.2	0.92
58	5.1	5.7	0.89
51	5.1	5.8	0.88
51	5.4	6.2	0.87
58	6.0	7.1	0.84

varies between specimens and even between whorls upon the same shell. Differences in definition of sculpture among the available specimens are also a function of wear and state of preservation of the specimen. Figure 8 on Plate 15 shows a specimen on which the sculpture of the base of the shell is obliterated by corrosion over part of the surface and contrasts strongly with the well-defined spiral and transverse elements present on the specimens shown in figures 6 and 7 on Plate 15.

Many of the specimens that retain most of the apex show loss of the protoconch and some solution of the shell surface, but a few show the dominant transverse ribbing of the early whorls (Pl. 15, figs. 1,9). The interior ridges of the outer and basal lips begin several millimeters behind the lip edge (Pl. 15, figs. 5,8; Pl. 16, fig. 4) and continue well into the shell (Pl. 15, fig. 8). Development of the parietal spiral ridge also appears to be a late-stage development (Pl. 15, fig. 5).

Denticulabrum laevigatum differs from *D. duckettsensis* in lacking pronounced development of spiral cords over much of the whorl sides. In addition, the columellar plication of *D. laevigatum* is more massive (contrast figures 4 and 5 on Plate 16), and the upper tooth of the outer lip becomes bidentate.

Occurrence.—Jamaica: Central inlier, Slippery Rock Formation at locality 30 and Guinea Corn Formation at locality 35; Maldon inlier, Shaw Castle Shale at localities 46 and 47; Marchmont inlier, "Titanosarcolites limestone" at localities 48, 51, 53, 56, 58, 59 (type locality), 60, 61, 62, 63, 64, and 65.

Age.—Maastrichtian.

Types.—Holotype USNMNH 468158; paratypes USNMNH 468159, 468160, 468161, 468162, 468163, 468164, 468165.

Denticulabrum duckettsensis Sohl, new species

Plate 16, figures 1–3, 5, 6; plate 17, figures 1–10

Diagnosis.—Shell small, trochiform; early whorls flat sided, body whorl with expanded and rounded periphery. Spiral sculpture usually consists of five noded spiral cords on whorls of spire; subsutural spiral most prominent.

Description.—Shell, moderately small, trochiform; protoconch poorly known, but small; earliest two to three teloconch whorls rounded, subsequent several whorls with flat sides, whorls of latest growth stages with concave upper whorl profile that grades to inflated and rounded periphery. Pleural angle 63° to 67° on early parts of shell and 56° to 58° at maturity. Sculpture of earliest teloconch consists of transverse ribs; subsequent whorl sculpture dominated by spiral elements consisting of four spiral cords on early whorls and five to seven cords on later whorls; subsutural cord strongest, may become spiral ribbon raised above slightly grooved suture; subsutural cord commonly well separated from second cord; second to fifth cords of nearly equal strength that become progressively closer spaced toward smooth periphery; periphery abruptly rounds down to base; base bears fine spiral striae near periphery and three or four raised cords near axis. Spiral cords on whorl sides bear closely spaced, collabrally directed, subrectangular nodes; nodes strongest on subsutural cord and more variably developed on subsequent spiral cords.

Aperture wider than high; inner lip callus extending slightly onto basal surface; columellar lip short, thick, and bearing elongate, disclike plication; plication extends laterally and obliquely into aperture, but forward edge protrudes out of aperture, thus overhanging basal lip above, but merges with basal lip below; outer lip prosocline, sharp edged, thickening interiorly, where it bears five elevated ridges extending into shell interior; ridges decrease in strength anteriorly; basal lip sinuous and interiorly bearing two raised, coarse nodes that extend into shell with decreasing strength.

Etymology.—Named for the type locality near Ducketts Crossroads, Marchmont inlier, Jamaica.

Measurements.—Measurements for six specimens are given in Table 21.

Discussion.—Over 200 specimens from 17 localities in shales of the *Titanosarcolites*-bearing beds of the Upper Cretaceous of Jamaica are available for study.

In possession of an inflated whorl periphery and in general character of the aperture, *Denticulabrum duckettsensis* is similar to *D. laevigatum,* but differs most pronouncedly in the presence of the cords that cover the whorl sides and presence of a bifid spiral ridge high on the interior surface of the outer lip.

In general form of sculpture and whorl shape, young specimens of *D. duckettsensis* are similar to those of *Discotectus marchmontensis,* but early shell development differs (contrast figures 9 and 11 on Plate 17). In addition, *D. marchmontensis* lacks an inflated rounded periphery of the whorls at maturity.

Figures 1, 4, 6, and 7 on Plate 17 show a consistent pattern of the subsutural spiral cord being the strongest. The apparent close spacing of the spiral cords seen on figure 3 of Plate 17 is an artifact of perspective, as the whorls of the mature shell develop a concave upper whorl profile. The true spacing of the spiral cords is well shown on the specimens representing earlier growth stages such as that shown on Plate 17, figure 1. Variation in the strength of sculpture among the specimens figured is mainly a function of state of preservation. The interruption in trend of the spiral sculpture on the body and penultimate whorls of the specimen shown in figure 7 on Plate 17 was caused by shell damage and subsequent repair.

Occurrence.—Jamaica: Central inlier, Guinea Corn Formation at localities 31, 33, 35, 36, 37, 38, 39, 40, and 42; Maldon inlier, Shaw Castle Shale at locality 46; Marchmont inlier, "Titanosarcolites limestone" at localities 48, 49, 51 (type locality), 54, 55, 58, and 61.

Age.—Maastrichtian.

Types.—Holotype USNMNH 468166; paratypes USNMNH 468167, 468168, 468169, 468170, 468171, 468172, 468173, 468174, 468175, 468176.

Genus **STEGNOSTOMELLA** Sohl, new genus

Type species.—*Stegnostomella haughtonensis* Sohl, new species.

Diagnosis.—Shell moderately small, thick, trochiform, anomphalous; early whorls gently convex, followed by whorls that round down to an angulate junction with concavely flat base. Whorl sides with strong, raised, nodose to spinose spiral cords; base with fine spiral lirae crossed by adaperturally concave growth lines on early whorls that become spinose cords at maturity.

Early stage aperture highly inclined, much wider than high, columella short and twisted at base. Final aperture arcuately lenticular in outline, so inclined to axis that it virtually faces downward; aperture constricted by curved, protruding, and downturned columellar plication; plication continuous with basal lip; nodes and ridges present on final parietal surface; thick callus extends out of aperture and over most of concave base of body whorl.

Etymology.—From the Greek *stegnos,* constricted, and *stoma,* peristome.

Discussion.—*Stegnostomella* is known only from the type species that occurs in the upper Campanian deposits of Jamaica. The character of the final aperture is so distinctive, however, that generic separation is warranted. The conical form, concavely flat base, and highly inclined aperture are consistent with assignment to the Trochini.

The basal liplike downturned ridge of the aperture seems to mimic the low columellar disc of *Discotectus.* Thus, one might postulate derivation of *Stegnostomella* from a *Discotectus* ancestry. Unfortunately, knowledge of the early growth stage of the type species is incomplete, but what can be seen is that the base of the columella of the earlier stages appears to be somewhat twisted, more in the manner of *Tectus* than *Discotectus.*

Stegnostomella haughtonensis Sohl, new species
Plate 18, figures 1–11

Diagnosis.—*Stegnostomella* whose whorls bear six nodose to spinose spiral cords.

Description.—Shell characters same as for generic diagnosis. During growth, sides increase in degree of rounding, sutures become more deeply impressed, and pleural angle increases. Whorls bear six raised, round-topped spiral cords; nodes of variable strength on cord crests show tendency for development of subspinose elevation at adapertural ends; on later part of penultimate whorl and on body whorl, adaperturally directed, hollow spines develop on sixth or lowest cord. Spiral lirae on early whorls of concave shell base replaced by spinose spiral cords on body whorl. Transverse sculpture restricted to fine, collabral, highly inclined, prosocline growth lines on whorl sides that continue with arcuate trend over the base. Aperture of early growth stages poorly known, wider than high, and lenticular; columellar lip short and slightly twisted at base. Final aperture highly modified by callus deposits on margin, becoming virtually directed downward; callus extends out of aperture and almost completely covers base of body whorl; basal lip of aperture extends out of aperture as strong, round-topped ridge with downturned edge; junction of basal lip and outer lip in round-based channel; outer lip rounded, posteriorly terminating in groove; parietal wall with raised node near junction with outer lip; laterally, node grades to arcuate raised ridge over parietal wall extending beyond apertural margin onto shell base.

Etymology.—Named for Haughton Hall, Green Is-

Table 22.—Measurements of specimens of *Stegnostomella haughtonensis* from the Green Island inlier of Jamaica, most of which are missing a portion of the apex.

Height (mm)	Maximum diameter (mm)
11.2	10.5
9.8+	10.1
8.6+	10.6
9.5	8.3
8.5+	9.1

land inlier, Jamaica, near the type locality of the species.

Measurements.—Measurements of specimens from the Green Island inlier of Jamaica are given in Table 22. Most of these specimens are missing a portion of the apex.

Discussion.—Shells of *Stegnostomella haughtonensis* are especially common in the rubbly shales associated with the rudist-rich limestone of the Green Island Formation of the Green Island inlier of Jamaica. The more than 150 available specimens have all been replaced by crystalline calcite. A number of specimens show partial exfoliation of the outer shell layer separating it from a smooth-surfaced inner layer showing no reflection of the spiral cords of the shell surface. This inner shell layer is interpreted as the nacreous shell layer common to many trochaceans.

Development of spines on the spiral cords of the whorl sides and base is most consistent on the sixth or lowermost cord (Pl. 18, fig. 3). Spines become especially pronounced on the body whorl near the aperture (Pl. 18, fig. 1), where they may be inclined down below the plane of the whorl base. The close, almost imbricate spacing of the spines on the cords of the whorl base is well displayed on Plate 18, figure 8, where parts of the covering callus deposits have been spalled.

Plate 18, figures 4–11, show some of the phases in development of the final aperture. On younger shells, before formation of the apertural modifications, the base of the shell is covered by fine spiral lirae that are crossed by arcuate growth lines (Pl. 18, fig. 5). At this stage, the aperture lacks significant parietal callus. At early maturity, the callus ridge at the base of the aperture is a thick, raised, arcuate lip (Pl. 18, fig. 6). Subsequently, the ridge is extended laterally across the base toward the outer lip (Pl. 18, figs. 7, 8), where the margin curves and forms the raised margin of a channel between the basal and outer lips (Pl. 18, figs. 7–9). Thickening and increased elevation of the callus ridge accompany the lateral growth, resulting in a broad downturned lip that extends out of the aperture (Pl. 18, fig. 11).

Posteriorly, over the parietal surface of the base and margining the aperture, there is another elongate ridge. Initially (Pl. 18, fig. 8), this ridge begins near the junction of the outer lip and parietal surface and extends laterally across the latter surface. Toward the aperture, it is bounded by an elongate groove in the callus surface (Pl. 18, fig. 6). During later stages, the end of this ridge that lies toward the outer lip develops into a raised knob that bounds a posterior channel of the aperture (Pl. 18, figs. 9, 10, and posteriorly directed arrow of fig. 11). The concave, callus-covered base of the mature shell provides a broad surface amenable for clinging to a hard substrate. In essence, the inclination of the aperture to the growth axis has converted the trochiform shape of the early shell to a patelliform outline at maturity.

The recessed position of the aperture on the concave, callus-covered surface of the base, coupled with the confining marginal ridges that are directed downward, and the spinose basal periphery are similar to many of the characters seen in the shells of the Xenophoridae (Linsley and Yochelson, 1973). The channels formed by the lateral edges of the basal and parietal ridges may have served to direct inhalent and exhalent currents (arrows on Pl. 18, fig. 11). The combination of these shell characters—spinose basal periphery, concave base, orientation of the aperture—suggests that *Stegnostomella* may, like *Xenophora,* have been a deposit feeder.

Occurrence.—Jamaica: Sunderland inlier, Stapleton Formation at locality 44; Green Island inlier, Green Island Formation at localities 69 (type locality), 71, 72, 74, and 75.

Age.—Late Campanian.

Types.—Holotype USNMNH 468175; paratypes USNMNH 468176, 468177, 468178, 468179, 468180, 468181, 468182, 468183.

Genus **TECTUS** Montfort, 1810

Type species.—By original designation, *Trochus mauritanus* Gmelin, 1791.

Discussion.—Wenz (1938) and Keen and Cox (*in* Knight *et al.*, 1960, p. I260) both included *Cardinalia* Gray, 1847, and *Rochia* Gray, 1857, as subgenera of *Tectus.* Cossmann (1918) considered *Tectus* as an undivided genus and placed *Rochia* and *Cardinalia* as subgenera of *Trochus. Tectus (Tectus),* as it was diagnosed by Keen and Cox (*in* Knight *et al.*, 1960, p. I260), is restricted to higher than wide, anomphalous shells that have a smooth base, a columellar plication, and axial folds on the whorls of the spire. If their definition is accepted, most of the fossil species and many of the recent species currently assigned to *Tectus* s.s.

are excluded because of the presence of spiral rather than axial sculpture on the spire or on the shell base.

Both Wenz (1938) and Cossmann (1918) viewed *Tectus* broadly. They allowed greater latitude in type of sculpture than Keen and Cox (*in* Knight *et al.*, 1960, p. I260) and emphasized the unifying character of having a short columella that bears a twisted plait at its base. This plait is followed below by a notch that separates the basal lip. Within this broader definition, the shells described below are assigned to *Tectus*.

In general form and sculpture, *Tectus* shows similarities to *Discotectus*, especially to those species having an angulate periphery and flattened base. The columellar plait of *Discotectus* is a more complicated structure whose free end extends well into the aperture and whose disclike edge also protrudes forward out of the aperture and over the shell base. In *Tectus*, the plait is related to the twisting of the anterior part of the short columella.

Tectus has been cited by most authorities as ranging from the Cretaceous to the present. Stoliczka (1868) and Cossmann (1918) provided listings of Cretaceous species that they considered assignable to *Tectus;* these listings include some that occur as early as the Valanginian and range upward to the Maastrichtian. More recently, Olsson (1944), Allison (1955), and others added additional taxa. Unfortunately, many of the species are based upon material that preserves the apertural characters insufficiently well for confident placement. Until the type material of such species can be critically reexamined or until better preserved material can be found, a definitive answer as to the earliest occurrence of the genus must remain in doubt.

The living species of *Tectus* are confined to the warmer waters of the western Indo-Pacific area. The Cretaceous Caribbean species described below were also inhabitants of warm, shallow marine environments. Other Cretaceous species have been described from Baja California, Peru, southern India, the Middle East, and various parts of Europe.

Tectus revesensis Sohl, new species
Plate 18, figures 12–18

Diagnosis.—Whorls bear four noded spiral cords; subsutural cord bears strongest nodes.

Description.—Shell moderately small, conical, higher than wide, anomphalous. Pleural angle about 45° on early parts of shell, increasing to 54° at maturity. Early whorls with flat sides above a sharply angulate periphery; later whorls slightly concave between grooved suture and midwhorl, then expanding to angulate periphery. Base smooth, flat, and adapically inclined on early whorls, but becoming virtually horizontal to axis on body whorl except for narrow excavated area bordering pillar. Whorls bear four elevated, noded and round-topped spiral cords; cords narrower than spiral interspaces; adapical cord margins suture and bears strongly raised, discrete nodes that are stronger and more widely spaced than nodes on following spirals; fourth spiral only weakly noded and forms peripheral whorl angulation. Aperture wider than high, outer lip prosoclinely inclined at low angle to axis; parietal surface broadly arched and abruptly rounding to short columella; columellar lip concave, terminating anteriorly in short, but pronounced plication; basal lip very gently convex, but sharply rounding interiorly at junction with outer lip.

Etymology.—Named for its occurrence in the Revés Member of the Pozas Formation.

Measurements.—All the available specimens are incomplete. The largest shells only slightly exceed 10 mm in height and are about 9.5 mm in diameter.

Discussion.—Twenty-two specimens, all from the Revés Member of the Pozas Formation in the Barranquitas quadrangle of Puerto Rico, are available for study. The presence on the whorl sides of only four spiral cords and the suppression of noding on the fourth or peripheral cord are characters not found in the other species of *Tectus* described herein. *Tectus berryhilli* is the most similar species in form and sculpture, but possesses five instead of four spiral cords on the whorl sides, is more slender, and has a less inflated periphery. Variation in strength of sculpture among the specimens illustrated on Plate 18 is mainly a function of specimen preservation, but variation in shape of the nodes is a function of ontogenetic stage. With increased growth, the nodes upon the spiral cords tend to become spirally elongate. This feature is especially pronounced on the subsutural spiral, and, there, such elongation and increased spacing of nodes may appear at an early stage of development (Pl. 18, fig. 18). The change in whorl profile with growth is well shown in the specimen figured on Plate 18, figures 15 and 17, which depicts the change from flat-sided early whorls to the late stage development of an expanded periphery that overhangs the subsequent whorl.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Revés Member of the Pozas Formation at localities 11 and 12 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468184; paratypes USNMNH 468185, 468186, 468187.

Tectus berryhilli Sohl, new species
Plate 19, figures 1, 2

Diagnosis.—Whorls bear five closely spaced, noded spiral cords, with peripheral cord being strongest.

Description.—Shell moderately small, slightly coeloconoid, higher than wide, and anomphalous. Pleural angle about 37° on early whorls, increasing to 42° at maturity. Suture incised, whorl sides virtually flat, periphery angulate; base concavely rounded between periphery and midlength, central area flattened, becoming steeply inclined or excavated adapically marginal to pillar. Whorl sides bear five noded and raised spiral cords; cords wider than interspaces; first cord abuts suture; fifth and most prominent cord situated at whorl periphery, has suppressed noding. Base bears a few, faint, widely spaced spiral threads and arcuate growth lines. Aperture incompletely known; columellar lip excavated and bearing plication at base.

Etymology.—Named for Henry L. Berryhill, Jr., who mapped the geology of the Central Aguirre quadrangle wherein the type locality of the species occurs.

Measurements.—The holotype (USNMNH 468188), from locality 2 in the Coamo Formation of the Central Aguirre quadrangle of south-central Puerto Rico, is incomplete, lacking the extreme apical tip. As preserved, the specimen measures 9.1 mm in height and 8.2 mm in diameter and has a body whorl 2.6 mm high.

Discussion.—Only three specimens of *Tectus berryhilli* are known, and none has a complete aperture, but the concave nature of the base, the excavated area contiguous to the pillar, and the short columella are all consistent with placement in *Tectus.* The presence of only five spiral cords on the whorls is sufficient to distinguish *T. berryhilli* from the other described forms. In addition, *T. revesensis* has wider spaced spiral cords, has a less concave base, and is proportionally broader. *Tectus kauffmani* (described below) has more numerous spiral cords on the whorls and lacks distinct noding of those cords.

Occurrence.—Puerto Rico: Central Aguirre quadrangle, Coamo Formation at locality 2 (type locality).

Age.—Maastrichtian.

Type.—Holotype USNMNH 468188.

Tectus kauffmani Sohl, new species
Plate 19, figures 8, 11–13

Diagnosis.—Conical shells with concave shell base; whorls bear six primary spiral cords.

Description.—Shell, medium size, conical, higher than wide, and anomphalous. Pleural angle about 52°. Suture incised; whorls with very narrow inclined subsutural ramp, followed by flat sides that terminate in angulate periphery that slightly overhangs subsequent whorl. Shell base flatly concave, slightly excavated adjacent to pillar. Whorl sides bear six raised, round-topped spiral cords; faint secondary cord may occur between suture and first primary cord; upper three primary cords closely spaced and narrower than lower three cords; lower two cords closely spaced, and lowest, or sixth, primary cord situated at shell periphery; prosocline growth lines inclined about 30° to sutural plane; growth lines form prosoclinely elongate, low swellings where they override spiral cords, but are thin threads in cord interspaces. Shell base most noticeably marked by six or seven narrow, widely spaced, incised spiral grooves on inner one-half of surface; growth lines faint and arcuate in trace. Aperture incompletely known, subrectangular and wider than high; outer lip inclined; parietal surface junction with columella sharply subrounded; columella, short, inclined, curved, and terminating anteriorly in a short plait, followed by a shallow notch; basal lip thin, straight, junction with outer lip angulate.

Etymology.—Named for Erle G. Kauffman in recognition of his many contributions to Cretaceous stratigraphy and paleontology.

Measurements.—All specimens are from the Green Island Formation of western Jamaica and are incomplete. The holotype (USNMNH 468189) measures 13.5 mm in diameter and 4.0 mm in body whorl height and has an estimated shell height of 16 mm.

Discussion.—The combination of larger size, greater number of spiral cords, and subdued character of noding of the spiral cords readily distinguishes *Tectus kauffmani* from *T. berryhilli* and *T. revesensis.* In addition, *T. kauffmani* occurs within the range of *Barrettia gigas,* at a lower stratigraphic level than the other two species.

The lower two spiral cords of the whorl sides form a couplet on the early whorls. In early stages of development, they appear to be joined as subdivisions of a raised spiral ribbon and are separated only by a spiral groove. On later whorls, separation of the two cords becomes more distinct, with the peripheral, or lowest, cord being the more weakly developed. The holotype (Pl. 19, fig. 8) shows no evidence of development of secondary spiral cords, but one paratype (Pl. 19, fig. 13) shows intermittent presence of a faint cord placed between the suture and the first subsutural primary spiral cord.

Occurrence.—Jamaica: Green Island inlier, Green Island Formation at localities 71 (type locality) and 72.

Age.—Late Campanian.

Types.—Holotype USNMNH 468189; paratype USNMNH 468190.

Tectus sp. A
Plate 19, figures 3–7, 9, 10

Discussion.—Several comparatively large specimens from limestones within the El Rayo Formation of the Sabana Grande quadrangle of southwestern Puerto Rico (locality 14) indicate the presence of an undescribed species of *Tectus.* Unfortunately, their condition of preservation is insufficient to provide a firm basis for formal specific designation.

They are the largest species of *Tectus* present in the Late Cretaceous materials dealt with here. The specimen shown on Plate 19, figure 10, measures 27 mm in diameter and more than 23 mm in height; the apical tip is incomplete. Only faint traces of spiral sculpture are present on the whorl sides (Pl. 19, figs. 6, 7) and consist of six to seven spiral cords that bear low, widely spaced nodes. The most persistently preserved spiral element is a cord at the angulate basal periphery of the whorls. The base of the shell is concave with a flat, adapically inclined surface that bears traces of round-topped, widely spaced spiral cords (Pl. 19, fig. 9). The basal surface is excavated adjacent to the pillar. The aperture is much wider than high (Pl. 19, fig. 5). The columella is posteriorly excavated and thickens anteriorly to a terminal plaitlike swelling that is followed by a notch at the junction with the basal lip. The above-mentioned features are consistent with assignment to *Tectus,* but the condition of the specimens precludes close comparison with other described species. In general form, it differs significantly in both size and its proportionally lower shell from the other Antillean species here described.

Occurrence.—Puerto Rico: Sabana Grande quadrangle, El Rayo Formation at locality 14.

Age.—Maastrichtian.

Material.—Figured specimens USNMNH 468191, 468192, 468193, 468194.

Tectus variegatus Sohl, new species
Plate 20, figures 1–14

Diagnosis.—Whorls lacking spiral sculpture; peripheral angulation is sharp and overhangs subsequent whorls in late growth stages.

Description.—Shell conical, moderately small, higher than wide and consisting of about 12 or 13 whorls. Early whorls form flat-sided cone with pleural angle of about 40°. Later whorls expand more rapidly, pleural angle increases to 50°, and sharp peripheral angulation develops that overhangs subsequent whorl. With development of peripheral angulation, whorl side profile may become concave. Base flat to very gently convex over outer one-half of surface, then increasingly rounding down to deep excavation adjacent to pillar. Whorl sides and base devoid of sculpture. Aperture wider than high, sublenticular; outer lip thin, sharply angled at junction with basal lip; basal lip broadly curved, continuous with twist at base of short columellar lip.

Etymology.—From the Latin *variegatus,* of different sorts, referring to the variability in outline.

Measurements.—Most specimens are missing the apex or are slightly compressed. Measurements for the best preserved specimens are given in Table 23. Larger specimens than those measured are known but are incomplete. The largest of these exceeds 15 mm in height and 12 mm in maximum diameter.

Table 23.—Measurements for well-preserved specimens of *Tectus variegatus.* Most specimens are missing the apex or are slightly compressed.

Locality	Height (mm)	Maximum diameter (mm)	H:MD
51	9.5+	7.8	—
52	12.0	8.5	1.4
52	12.5	8.6	1.4
41	13+	9.5	—
52	10+	8.4	—

Discussion.—*Tectus variegatus* is the best represented of the species of *Tectus* occurring in the Upper Cretaceous of the Antillean region. Over 150 specimens have been collected from 11 localities within the Central and Marchmont inliers of Jamaica. The species is readily distinguished from the other Caribbean species described herein in lacking pronounced spiral sculpture. In this character, it is atypical of the genus, but the presence of a twist or fold low on the columella is diagnostic (Pl. 20, figs. 7, 8, 12, 14). *Tectus tamulicus* Stoliczka, 1868, from the Arialoor Group of India, approaches this species in its lack of sculpture but differs in being broader relative to height and in having a curved columellar lip.

The early growth stages of *T. variegatus* possess whorls having flat sides and a barely impressed suture that results in a slender, evenly tapering, conical form (Pl. 20, figs. 5 and 10). In later stages, the shell becomes proportionally broader as an angulate periphery develops (Pl. 20, figs. 2, 4, 11). The point at which the peripheral angulation develops varies greatly between specimens as is shown among the specimens figured on Plate 20. In general, such an angulate periphery develops earlier on the proportionally broader shells.

Occurrence.—Jamaica: Central inlier, Guinea Corn Formation at localities 32, 33, 34, 35, 36, 39, and 41; Marchmont inlier, "Titanosarcolites limestone" at localities 51 (type locality), 52, 54, and 58.

Age.—Maastrichtian.

Types.—Holotype USNMNH 468195; paratypes USNMNH 468196, 468197, 468198, 468199, 468200, 468201, 468202, 468203, 468204.

Tectus sp.

Discussion.—Specifically indeterminate specimens of *Tectus* occur at a number of localities in Upper Cretaceous rocks of both Puerto Rico and Jamaica. These records not only extend the geographic range of the genus on the two islands, but also extend the stratigraphic range to include both the Santonian (locality 13) and youngest fossiliferous Cretaceous deposits (localities 77 and 79).

Occurrence.—Puerto Rico: Central Aguirre quadrangle, Coamo Formation at locality 3; Barranquitas quadrangle, Revés Member of the Pozas Formation at localities 8 and 9; Orocovis quadrangle, Río Bauta Member of the Pozas Formation at locality 13; San German quadrangle, El Rayo Formation at locality 21. Jamaica: Central inlier, Guinea Corn Formation at localities 35 and 43; Marchmont inlier, "Titanosarcolites limestone" at locality 64; Jerusalem Mountain inlier, Thicket River Limestone Member of the Jerusalem Mountain Formation at localities 77 and 79.

Tribe **CANTHARIDINI** Cotton, 1959

Genus **JUJUBINUS** Monterosato, 1884

Type species.—By subsequent designation (Pilsbry, 1889), *Trochus matoni* Payraudeau, 1827.

Diagnosis.—Shell small, turbiniform, with marked basal periphery and small columellar tooth.

Discussion.—Cretaceous shells assigned to this genus are few. Cossmann (1918, p. 291) placed *Tectus junceus* Stoliczka, 1868, from the Arialoor Group of southern India, in *Jujubinus,* and Abbass (1963) added *Jujubinus (Jujubinus) roashensis* from Cenomanian deposits at Abu Roash, Egypt. If better known, other Cretaceous species may prove to belong in this group, but such assignment must await further investigation.

Jujubinus botijasensis Sohl, new species

Plate 21, figures 8–14

Diagnosis.—*Jujubinus* with subangulate basal periphery and fine, incised spiral grooves covering whorl sides and base.

Description.—Shell small, anomphalous, turbiniform. Pleural angle near 85° on earliest whorls, decreases with growth to 50° at maturity. Suture incised. Whorls slightly concave over upper part, but broadly and convexly rounded below to suture; body whorl with rounded periphery; basal periphery roundly angulate; base broadly convex. Sculpture consists of microscopic, incised spiral lines with broader interspaces covering whorl sides and base; growth lines faint, prosocline, inclined about 55° from trace of suture. Aperture interrupted, subovate in outline; outer lip broadly rounded, thickened internally with four spiral ridges arising about one-eighth volution behind lip edge; inner lip broadly concave; columella rather direct, with low node at midlength.

Etymology.—Named for the village of Botijas in Barrio Botijas, Municipio de Barranquitas, Puerto Rico.

Measurements.—The holotype (USNMNH 468205) measures 5.8 mm in height and 4.8 mm in maximum diameter. The largest specimen, a paratype (USNMNH 468206), measures 8.0 mm in height and 5.2 mm in maximum diameter.

Discussion.—*Jujubinus botijasensis* is common, but restricted in occurrence to localities 4 and 5, in the Botijas Limestone Member of the Pozas Formation of Puerto Rico. The species occurs in the matrix of a rubbly limestone and is associated with abundant specimens of the bivalve *Plicatula* and the neritid gastropod *Pileolus.*

The subdued nature of the spiral sculpture of *J. botijasensis* (Pl. 21, fig. 14) is somewhat atypical compared to that of the type and most living species but is similar to that of such fossil species as *J. (J.) roashensis* Abbass, 1963, from the Cenomanian of Egypt. These spirals consist of fine incised lines that are much narrower than their spiral interspaces (Pl. 21, fig. 13). The ridges formed on the interior surface of the outer lip (Pl. 21, fig. 9) begin about 1 mm behind the apertural margin and die out internally after about one-quarter of a whorl. Presence or absence of such ridges seems to be a variable feature among other species assigned to the genera of the Cantharidini.

Occurrence.—Puerto Rico: Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation at localities 4 (type locality) and 5.

Age.—Late Campanian.

Types.—Holotype USNMNH 468205; paratypes USNMNH 468206, 468207, 468208.

Subfamily **SOLARIELLINAE** Powell, 1951

Genus **SOLARIELLA** Wood, 1842

Type species.—By monotypy, *Solariella maculata* Wood, 1842.

Diagnosis.—Shell small, turbiniform, whorls rounded; umbilicus broad, deep and margined by noded spiral cord; aperture nearly radial.

Discussion.—The number of Cretaceous species assigned to *Solariella* is not great, but the species range from the Barremian through the Maastrichtian, as follows:

Eumargarita (Solariella) wassyencis Gillet, 1921, Barremian, France;
Solariella pellati Cossmann, 1900, Barremian, France;
Solariella belsfayensis Delpey, 1939, Aptian, Lebanon;
Eumargarita (Solariella) douvillei Cossmann, 1918, Albian, Egypt;
Solariella stewarti Murphy and Rodda, 1960, Albian, California;
Margarita (Solariella) newberryi Cragin, 1894, Albian, Kansas;
Solariella tarfayensis Collignon, 1972, Albian, Morocco;
Solariella radiatula occidentalis Whiteaves, 1903, Upper Cretaceous, British Columbia;

Solariella strangulata Stoliczka, 1868, Cenomanian, India;
Solariella turonica Cossmann, 1896, Turonian, France;
Solariella belestensis Delpey, 1942, Maastrichtian, France;
Solariella antonibensis Collignon, 1949, Maastrichtian, Madagascar.

In addition, various authors have assigned Cretaceous species originally described under such names as *Trochus, Margarita,* and others to *Solariella.* The common denominator in assigning all these species to *Solariella* is the presence of an umbilicus margined by a spiral row of nodes. The list includes forms with spires that range from low to high. Sculpture patterns range from smooth species to those having numerous spiral cords, some of which are noded.

The apertural features for many species are poorly known, and much further study is needed before all the species can be confidently placed. A similar spectrum of morphologies is shown, however, among the species assigned to *Solariella* from the Eocene of the U.S. Gulf of Mexico Coast (Palmer, 1937). It is in this broad sense of *Solariella* that the species described below is assigned to the genus.

Solariella marchmontensis Sohl, new species
Plate 21, figures 1–7

Diagnosis.—Shell small, wider than high, whorls with excavated subsutural ramp and well-rounded sides that bear very fine spiral threads.

Description.—Shell small, consisting of about five whorls; pleural angle about 95°; protoconch small, rounded, and less than one whorl. Initial whorl round sided for about three-quarters of a turn, then developing narrow, flattened, adaxially inclined ramp between suture and angulate shoulder; whorl side rounded below angulation; subsutural ramp may be lost on last one-half whorl of body. Rounded base terminated by noded spiral welt that bounds broad and open umbilicus; umbilical wall bears spiral cord that terminates at about midpoint of inner lip of aperture. Sculpture consists of fine spiral lines that shown faint nodes on earliest whorls but not on later whorls; growth lines faint and slightly prosocline.

Aperture incompletely known, outer lip rounded or flattened posteriorly at junction with subsutural ramp; inner lip arcuate, slightly thickened at base of columella in conjunction with terminus of umbilical spiral welt.

Etymology.—Named for the town of Marchmont, Westmoreland Parish, Jamaica.

Measurements.—The holotype (USNMNH 468209) measures 8.0 mm in diameter and 6.3 mm in height; a paratype (USNMNH 468210) is 9.0 mm in diameter and 6.3 mm in height.

Discussion.—*Solariella marchmontensis* is known from 19 specimens, all occurring in a lagoonal, muddy calcarenite unit at the type locality (locality 65, Text-fig. 20) northwest of Marchmont, Westmoreland Parish, Jamaica. The presence of the excavated subsutural ramp (Pl. 21, fig. 3), coupled with the presence of only very faint spiral sculpture (Pl. 21, fig. 4), separates this species from all other Cretaceous forms described as *Solariella.* In general form, *S. marchmontensis* is similar to some species described as *Calliomphalus* from Campanian and Maastrichtian units of the U.S. Gulf of Mexico Coastal Plain, especially *Calliomphalus (Calliomphalus) nudus* Sohl, 1960. All members of that species group, however, possess transverse ribs on the early whorls that, on later whorls, give way to noded spirals on the subsutural ramp and at the shoulder. As shown on Plate 21, figure 6, the initial whorls of *S. marchmontensis* bear only spiral elements.

Occurrence.—Jamaica: Marchmont inlier, "Titanosarcolites limestone" at locality 65 (type locality).

Age.—Maastrichtian.

Types.—Holotype USNMNH 468209; paratypes USNMNH 468210, 468211, 468212, 468213.

Subfamily **UMBONIINAE** Adams and Adams, 1854

As viewed by Hickman and McLean (1990), the verifiable fossil record of the Umboniinae is mainly Tertiary, but they did cite *Trochus grayi* Lees, 1928, from the Cretaceous (Maastrichtian) of Oman, as a possible member of the tribe Umboniini. The species described below is further indication of Cretaceous derivation of the group.

Tribe **MONILEINI** Hickman and McLean, 1990

Genus **CAMITIA** Adams and Adams, 1854

Type species.—By original designation, *Camitia pulcherrima* Adams and Adams, 1854.

Diagnosis.—Shell small, spire depressed; aperture transverse, columella anteriorly produced to a lamellar projection; umbilicus covered by callus.

Discussion.—Because of the distinctive character of the columellar projection *Camitia* usually has been classified as a subgenus of *Clanculus* Montfort, 1810, within the Trochinae. Hickman and McLean (1990, p. 35) have, on other considerations, placed the genus in the Monileini.

Subgenus **MICATIA** Sohl, new subgenus

Type species.—*Camitia (Micatia) plicata* Sohl, new species.

Diagnosis.—Shell moderately small, wide cone; base gently concave, with umbilical depression filled by callus. Whorls may have subsutural row of faint nodes or spiral lirae; base with low, spiral cords that become noded near umbilical depression where crossed by transverse welts. Aperture inclined to axis and with disclike projection arising from base of columellar lip and extending slightly out of aperture above basal lip.

Etymology.—By anagram from *Camitia.*

Discussion.—*Micatia* shares its low conical, sublenticular form and noded umbilical margin with many other members of the tribe Monileini. The presence of an apertural plication allies *Micatia* with *Camitia,* but the form and strength of this disclike plication also serve to separate the two. *Micatia* is currently known only from the type species, which occurs in abundance in calcareous, fine-grained, shallow marine sediments in the Maastrichtian of Jamaica.

Camitia (Micatia) plicata Sohl, new species

Plate 22, figures 1–14

Diagnosis.—As for subgenus.

Description.—Shell moderately small, spire low and conical, suture impressed. Protoconch imperfectly known, small, rounded and less than one whorl. Whorl sides flat to faintly convex, periphery sharply rounded; base nearly flat with medial sharply bounded depression that becomes filled with callus. Sculpture faint and variably developed above periphery, smooth or noded subsutural spiral cord commonly present followed below by few, widely spaced, incised spiral lines or lirae. Sculpture more pronounced on shell base than sides; spiral cords may cover base, becoming coarser and stronger marginal to central depression; transverse welts arise about halfway across base and may be accentuated to nodes where they cross broad, spiral cords adjacent to central depression. Aperture lenticular in outline; outer lip incompletely known, but prosoclinely inclined to axis; basal lip broadly sinuate; inner lip short with callus extending into and filling central depression of base; columellar lip with disclike plait extending from base into and out of aperture above basal lip; plait coalesces with basal lip shortly behind leading edge.

Etymology.—From the Latin *plicatus,* meaning plicate.

Measurements.—Measurements for eight specimens are given in Table 24.

Table 24.—Measurement for eight specimens of *Camitia* (*Micatia*) *plicata.*

Locality	Height (mm)	Maximum diameter (mm)	H:MD
43	3.8	6.9	0.55
43	3.5	6.1	0.57
43	3.5	6.5	0.54
63	3.4	5.9	0.58
43	3.1	5.1	0.61
63	2.8	4.6	0.61
63	2.6	4.5	0.58
43	2.1	3.5	0.60

Discussion.—*Camitia (Micatia) plicata* is represented by several hundred specimens in the material under study. At localities 43 and 63, it is the most common gastropod species and occurs mainly in shallow-water, nearshore, marine clays and silts. The progressive sequence of infilling of the umbilicus is shown in succession by figures 2, 6, 7, 10, and 13 on Plate 22. The most variable feature among specimens is the strength of sculpture, especially on the upper whorl face. There, the most consistent feature is the presence of a subsutural spiral cord that may be smooth (Pl. 22, fig. 9) or noded (Pl. 22, fig. 11). On the base of the shell, the most striking feature is the puckering or noding of the spiral elements marginal to the umbilicus (Pl. 22, figs. 2, 7, 8), a feature common to many species within the Monileini. The columellar plication is broken on many of the available specimens, but its thickness and position in later growth stages are shown at the arrow on figure 13 of Plate 22.

I am unaware of any other similar species among the known Cretaceous gastropod faunas.

Occurrence.—Jamaica: Central inlier, Guinea Corn Formation at localities 33, 35, 42, and 43: Marchmont inlier, "Titanosarcolites limestone" at localities 52, 63 (type locality), 64, and 65.

Age.—Maastrichtian.

Types.—Holotype USNMNH 468214; paratypes USNMNH 468215, 468216, 468217, 468218, 468219, 468220, 468221, 468222, 468223, 468224.

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PLATES

(All the illustrated specimens are deposited in the United States National Museum of Natural History in Washington, D.C. The plate captions provide the USNMNH specimen number for each illustrated specimen and the U.S. Geological Survey (USGS) Mesozoic locality number. SEM indicates views obtained by scanning electron microscope. Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Photographic library, Federal Center, Denver, CO 80225)

EXPLANATION OF PLATE 1

Figure Page

1, 4, 5, 9, 10, 13. ***Arene truncatosphaera*** Sohl, n. sp. 43

1. Apertural view (SEM: ×21) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 54 (USGS Mesozoic locality 33371; USNMNH 468036).

4. Back view (SEM: ×19) of a paratype from the same locality (USGS Mesozoic locality 33371; USNMNH 468037).

5. Apertural view (SEM: ×18) of a paratype from the same locality (USGS Mesozoic locality 33371; USNMNH 468038).

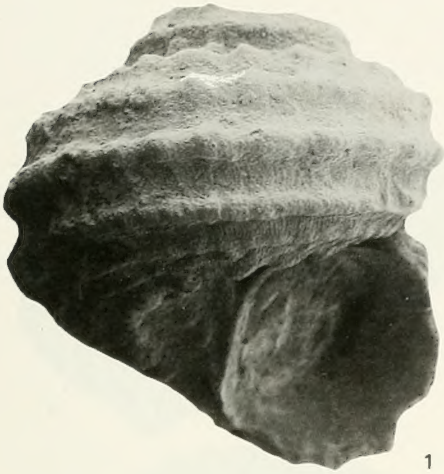
9. Apical view (SEM: ×15) of a paratype from the same locality (USGS Mesozoic locality 33371; USNMNH 468039).

10, 13. Apical (SEM: ×26) and basal (SEM: ×23) views of the holotype from the same locality (USGS Mesozoic locality 33371; USNMNH 468035).

2, 3, 6, 7, 8, 11, 12. ***Pseudoliotina mcleani*** Sohl, n. sp. 42

2, 3, 6, 7. Apical, basal, apertural, and back views (×5) of the holotype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29075; USNMNH 468033).

8, 11, 12. Apical, apertural, and basal views (×5) of a paratype from the same locality (USGS Mesozoic locality 29075; USNMNH 468034).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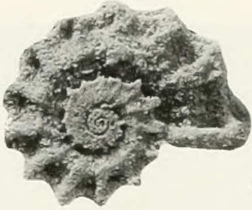
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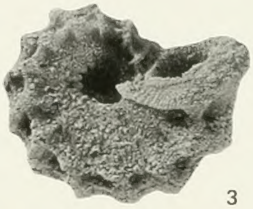
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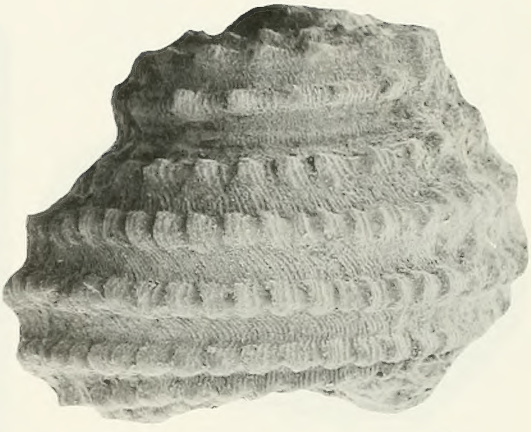
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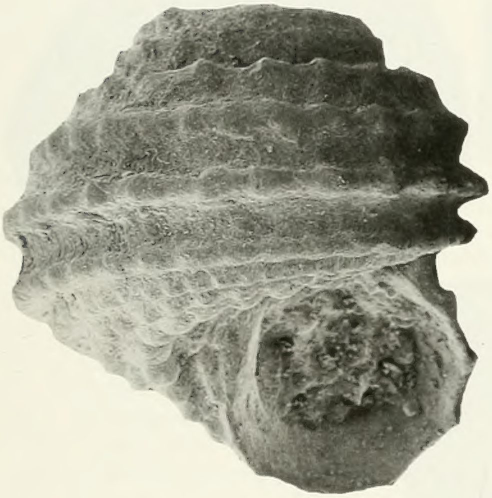
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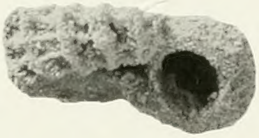
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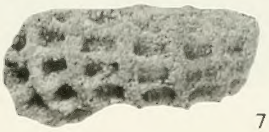
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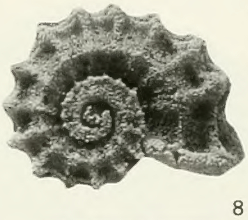
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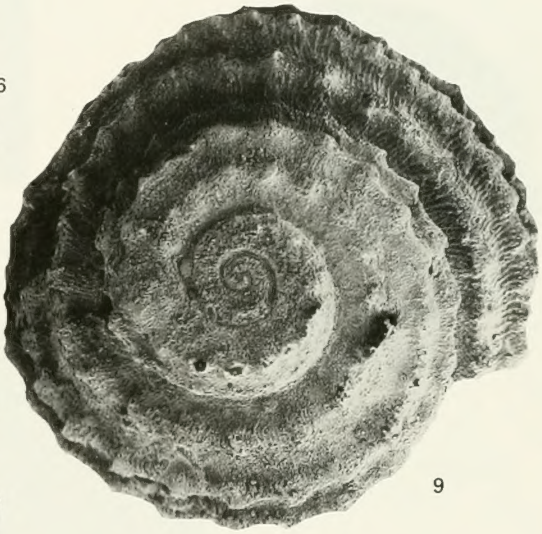
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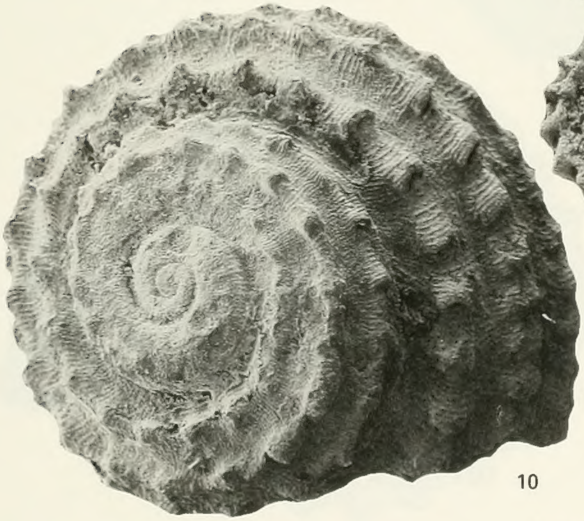
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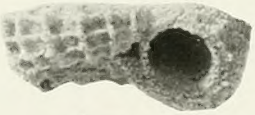
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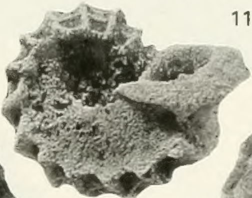
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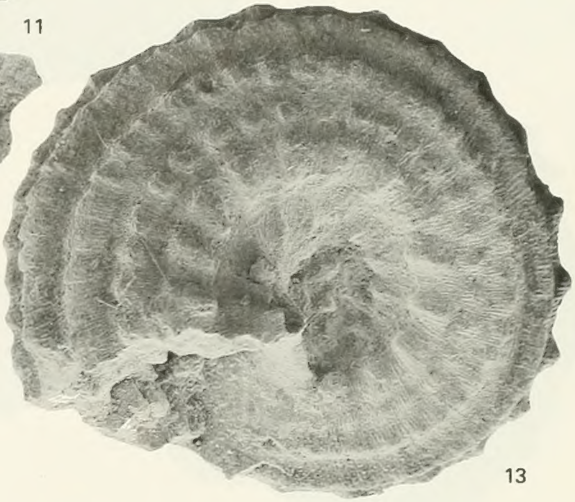
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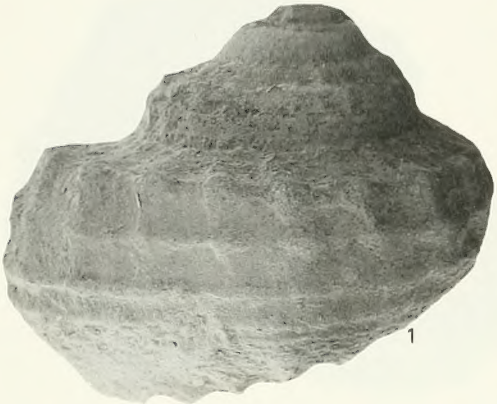
ARENE AND *PSEUDOLIOTINA*



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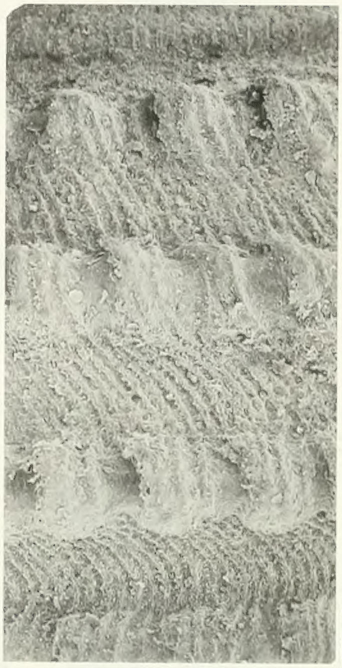

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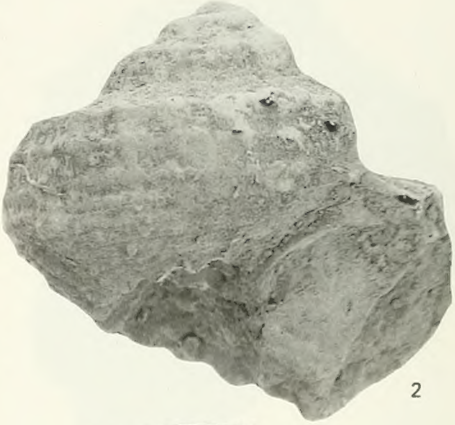

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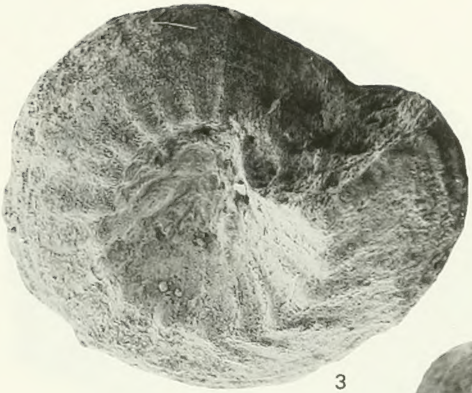

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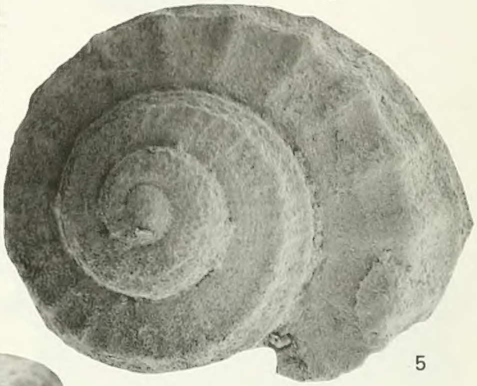

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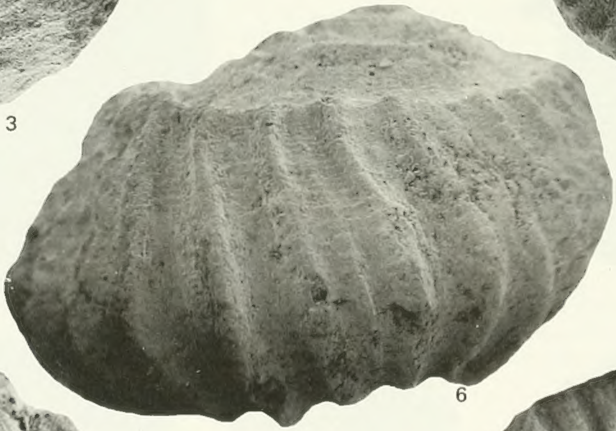

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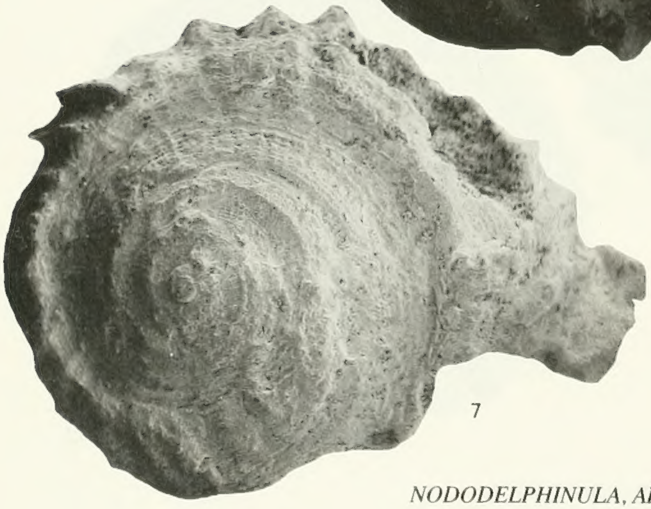

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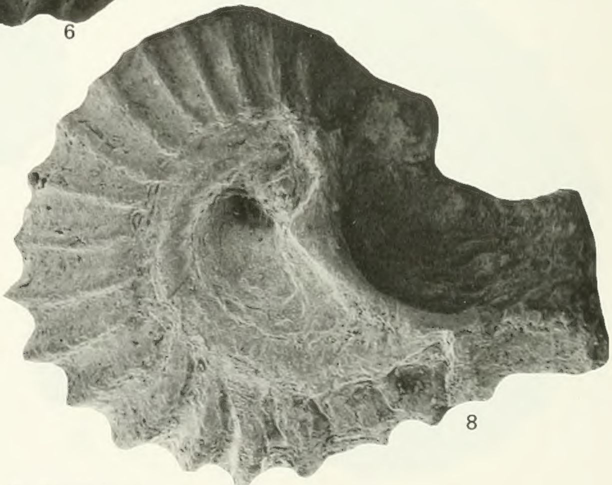

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NODODELPHINULA, ARENE AND *LIOTIINAE*

EXPLANATION OF PLATE 2

Figure Page

1, 2, 3, 5. ***Nododelphinula trechmanni*** Sohl, n. sp. 45

1. Back view (SEM ×30) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites", limestone at locality 65 (USGS Mesozoic locality 30493; USNMNH 468041).
2. Apertural view (SEM ×29) of the holotype from the same locality (USGS Mesozoic locality 30493; USNMNH 468040).
3. Basal view (SEM ×33) of a paratype from the same locality (USGS Mesozoic locality 30493; USNMNH 468042).
5. Apical view (SEM ×35) of a paratype from the same locality (USGS Mesozoic locality 30493; USNMNH 468043).

4. ***Arene truncatosphaera*** Sohl, n. sp. 43

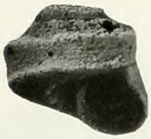
View of part of the specimen figured on Plate 1, fig. 4, enlarged (SEM ×54) to show details of sculpture.

6, 7, 8. **Liotiinae** undetermined. 44

Back (SEM ×21), apical (SEM ×16), and basal (SEM ×14) views of a specimen from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 4 (USGS Mesozoic locality 26802; USNMNH 468044).

EXPLANATION OF PLATE 3

Figure		Page
1–5.	***Nododelphinula? nudula*** Sohl, n. sp.	46
	Apertural, back, profile, basal, and apical views (×5) of the holotype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468045).	
6–8.	***Angaria?*** sp.	46
	Apical, back, and basal views (×6) of a specimen from Puerto Rico, Barranquitas quadrangle, Revs Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468048).	
9, 10.	**Colloniinae** operculum	48
	Outer and inner face (×5) of an operculum from Puerto Rico, San German quadrangle, Sabana Grande Formation, at locality 17 (USGS Mesozoic locality 30343; USNMNH 468053).	
11–16.	***Metriomphalus canabonensis*** Sohl, n. sp.	51
	11. Back view (×4) of a paratype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 30389; USNMNH 468076).	
	12, 13. Basal and apertural views (×4) of the holotope from the same locality (USGS Mesozoic locality 29365; USNMNH 468075).	
	14. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 30389; USNMNH 468077).	
	15. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 30389; USNMNH 468078).	
	16. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 29365; USNMNH 468079).	
17–22.	***Antillocollonia brujoensis*** Sohl, n. sp..	47
	17, 18. Apertural and basal views (×8) of a paratype from Puerto Rico, San German quadrangle, basal part of the Sabana Grande Formation, at locality 17 (USGS Mesozoic locality 30343; USNMNH 468050).	
	19–22. Profile, basal, back, and apertural views (×8) of the holotype from the same locality (USGS Mesozoic locality 30343; USNMNH 468049).	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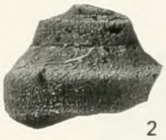
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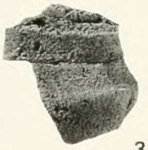
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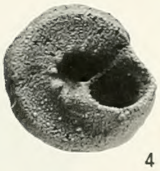
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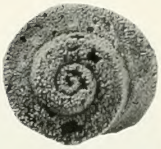
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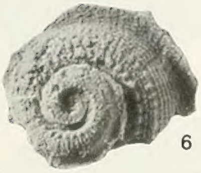
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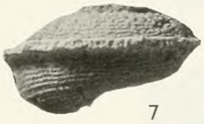
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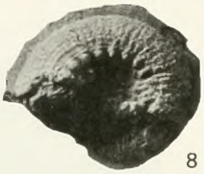
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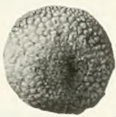
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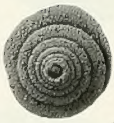
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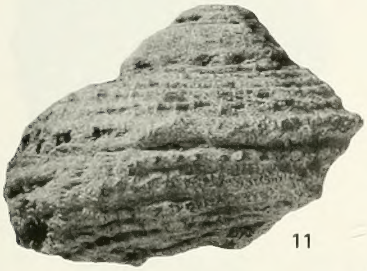
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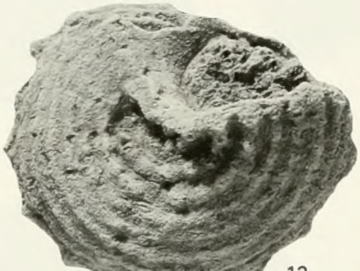
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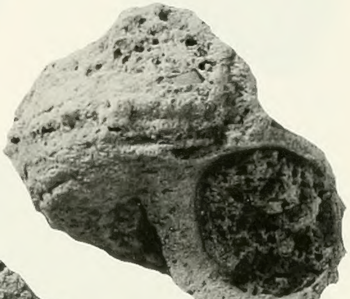
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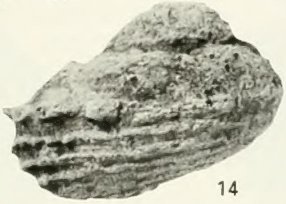
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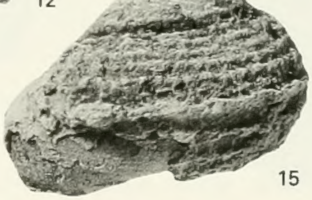
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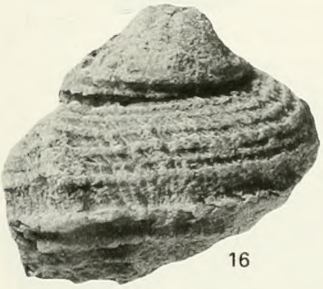
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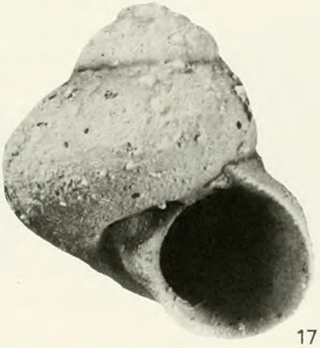
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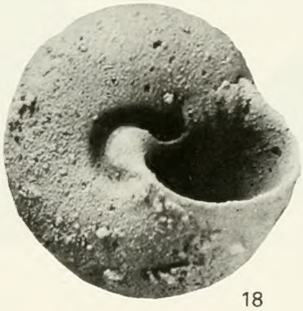
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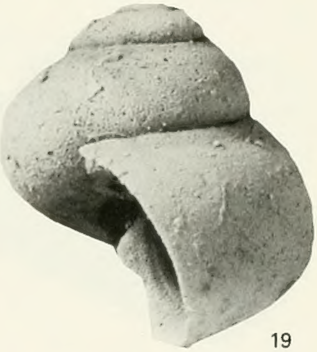
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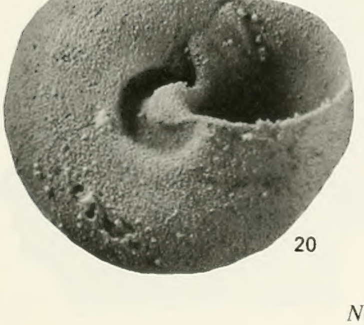
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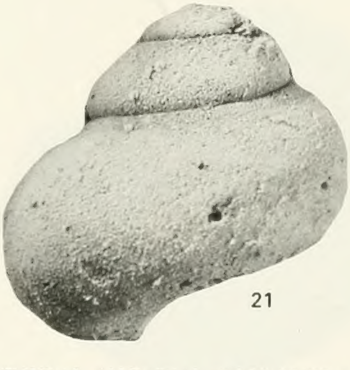
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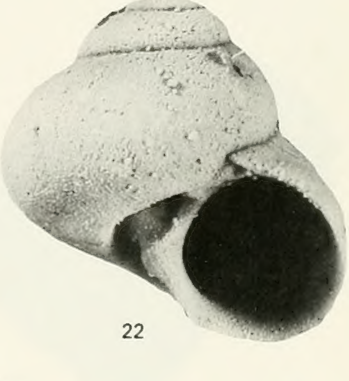
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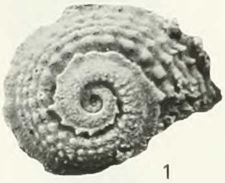
NODODELPHINULA?, *ANGARIA*?, *COLLONIINAE OPERCULUM*,
METRIOMPHALUS, AND *ANTILLOCOLLONIA*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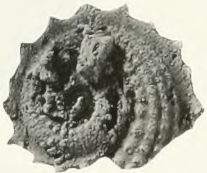
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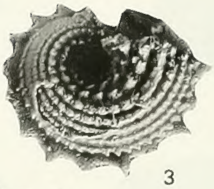
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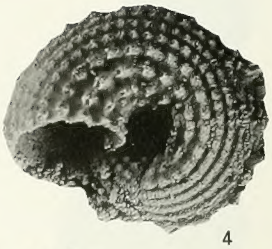
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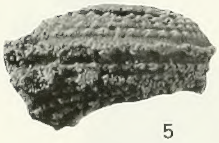
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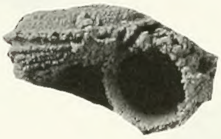
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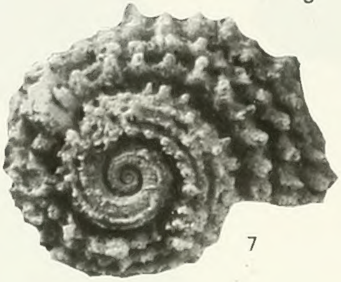
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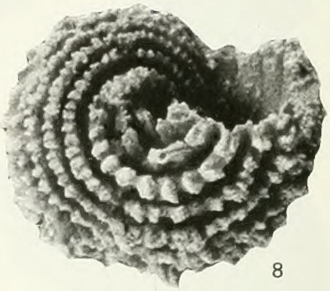
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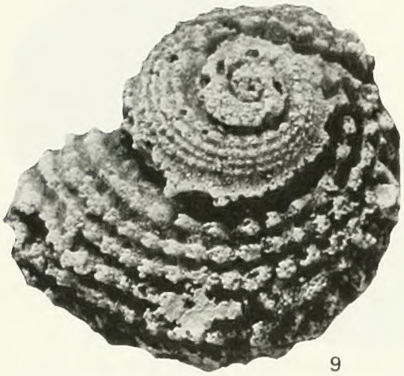
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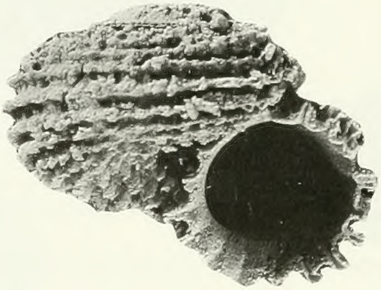
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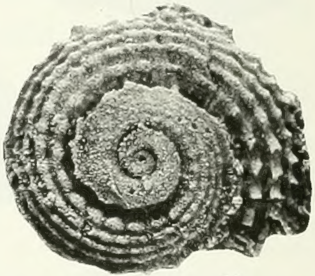
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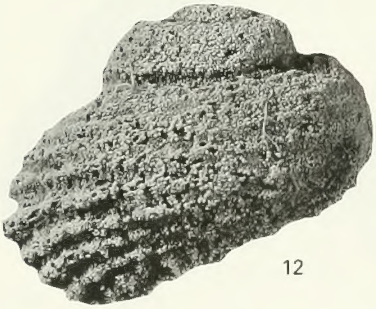
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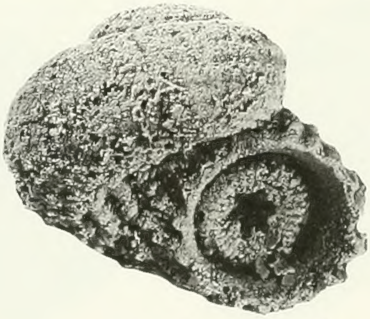
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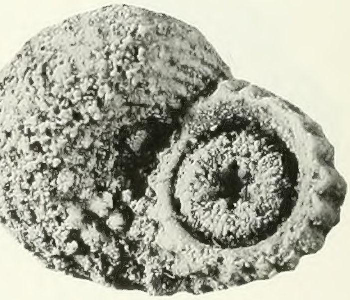
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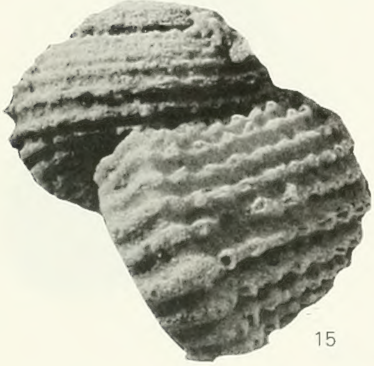
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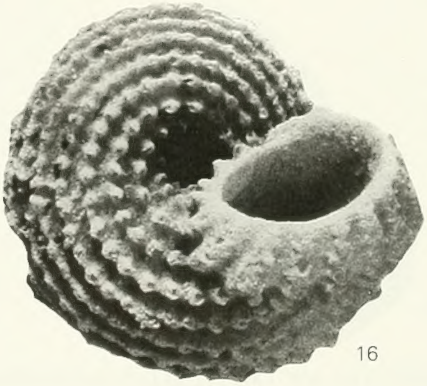
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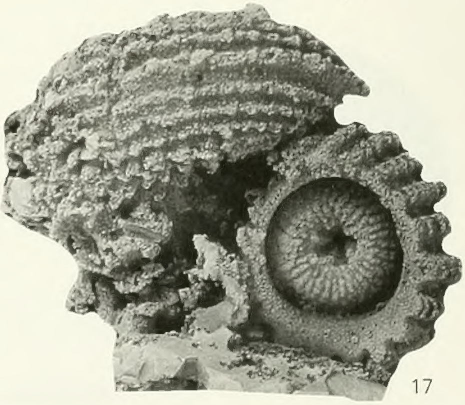
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EXPLANATION OF PLATE 4

Figure | Page

1–6, 9–17. ***Metriomphalus woodringi*** Sohl, n. sp. 49

1, 5, 6. Apical, back, and apertural views (×5) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 28748; USNMNH 468055).

2, 3. Apical and basal views (×5) of a paratype from the same locality (USGS Mesozoic locality 29075; USNMNH 468056).

4. Basal view (×5) of a paratype from the same locality (USGS Mesozoic locality 28748; USNMNH 468057), showing the open umbilicus.

9. Oblique apical view (×5) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468058).

10. Apertural view (×4) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468059), showing the fluting of the apertural lips.

11. Apical view (×5) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468060).

12–14. Back, apertural, and oblique basal views (×4) of a paratype from the same locality (USGS Mesozoic locality 28748; USNMNH 468061), showing form and depth of insertion of the operculum.

15, 16. Profile and basal views (×4) of the holotype from the same locality (USGS Mesozoic locality 29088; USNMNH 468054), showing tendency toward disjunct coiling of the late stage of the body whorl.

17. Apertural view (×4) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468062), showing operculum in place and the thickening of the final apertural lip.

7, 8. ***Metriomphalus horridus*** Sohl, n. sp. 50

Apical and basal views (×4) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468064). Note lack of spiny carination of early whorls and narrow umbilicus compared to similar views of specimens of *M. woodringi*.

EXPLANATION OF PLATE 5

Figure Page

1–20. ***Metriomphalus horridus*** Sohl, n. sp. 50

1–3. Front, oblique-apertural, and back views (×5) of a paratype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468065).

4. Apertural view (×4) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29075; USNMNH 468066).

5–8. Oblique-basal, profile, back, and apertural views (×5) of a paratype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468067).

9–12. Apertural, back, apical, and basal views (×2) of the holotype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468063).

13. Inner surface view (×3) of an operculum (paratype) from Jamaica, Green Island inlier, Green Island Formation, at locality 72 (USGS Mesozoic locality 30009; USNMNH 468068).

14. Profile view (×3) of an operculum (paratype) from the same locality (USGS Mesozoic locality 30009; USNMNH 468069).

15. Outer surface view (×7) of an operculum (paratype) from Jamaica, Green Island inlier, Green Island Formation, at locality 71 (USGS Mesozoic locality 30000; USNMNH 468070).

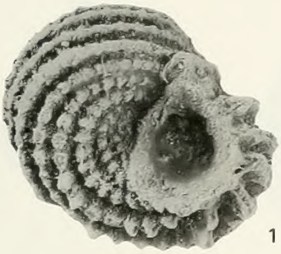
16. Outer surface view (×5) of an operculum (paratype) from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 10 (USGS Mesozoic locality 30388; USNMNH 468071).

17. Inner surface view (×6) of an operculum (paratype) from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468072).

18. Outer surface view (SEM ×31) of an operculum (paratype) from the same locality (USGS Mesozoic locality 30389; USNMNH 468073).

19. Apical view (×5) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468074).

20. Outer surface view (SEM ×31) of an operculum (paratype) from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 65 (USGS Mesozoic locality 30493; USNMNH 468101).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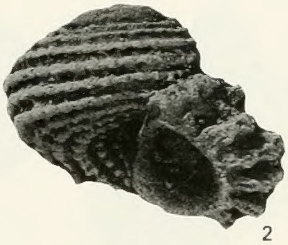
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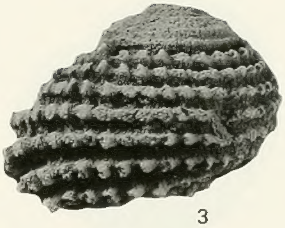
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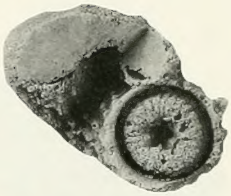
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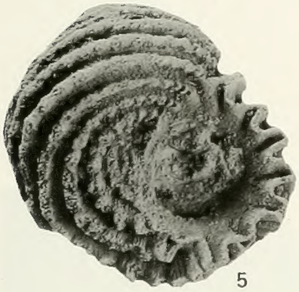
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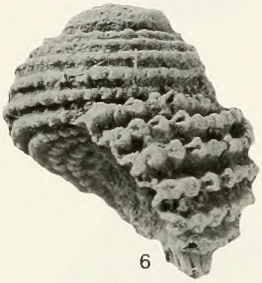
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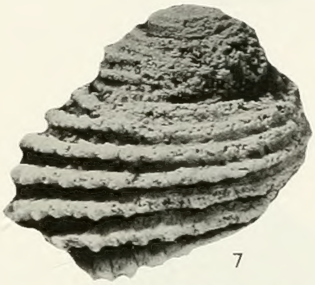
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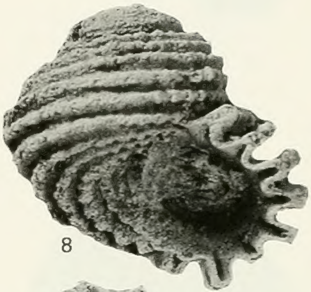
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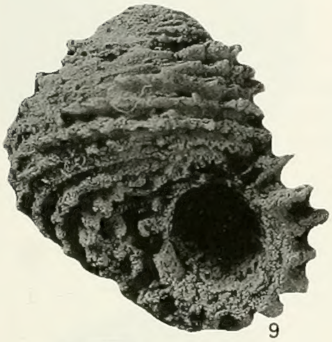
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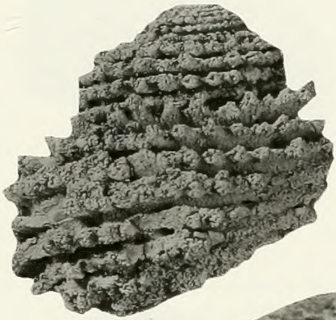
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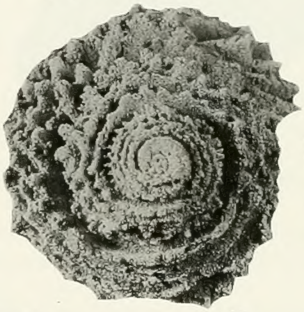
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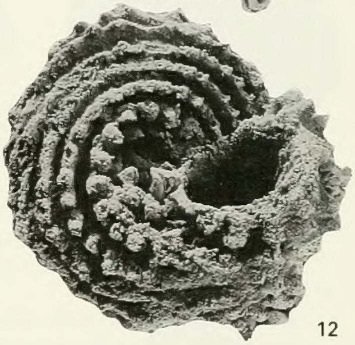
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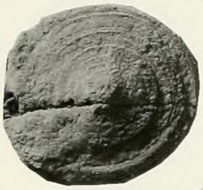
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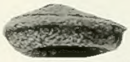
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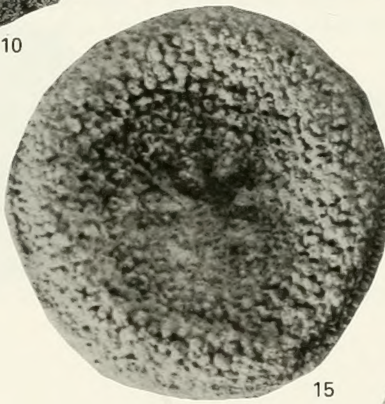
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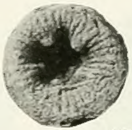
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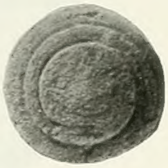
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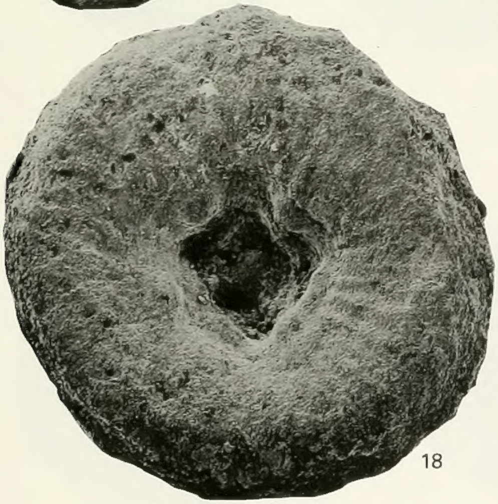
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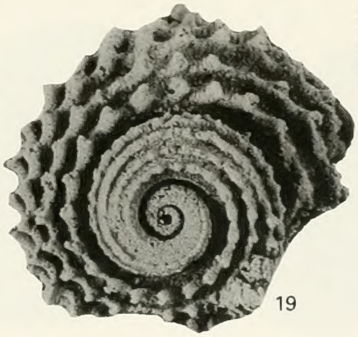
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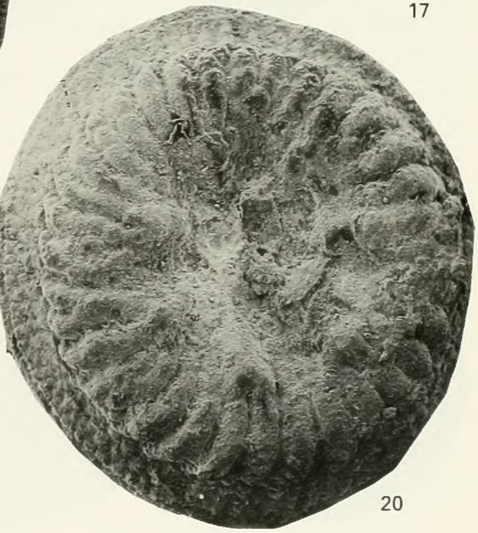
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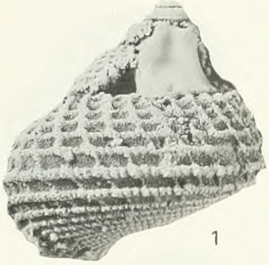
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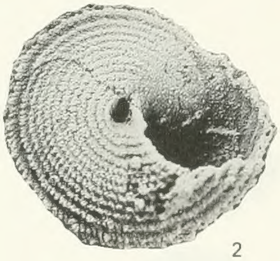
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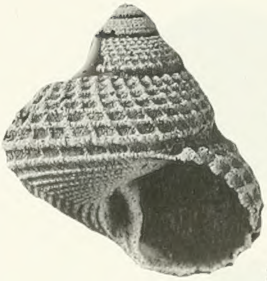
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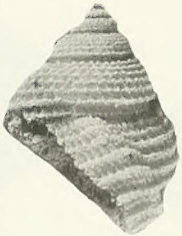
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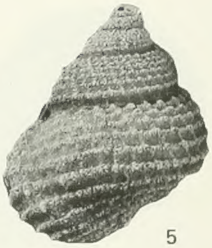
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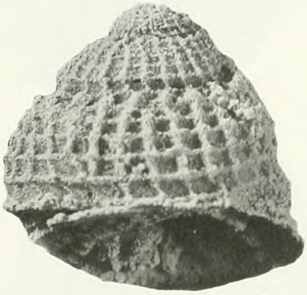
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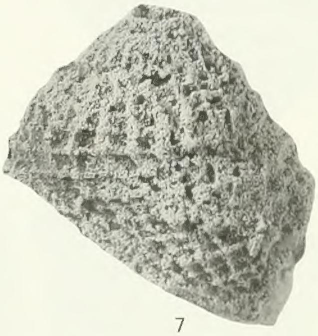
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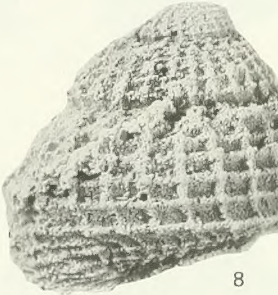
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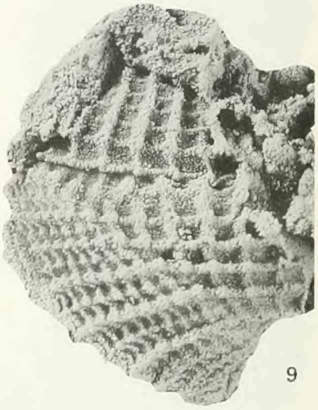
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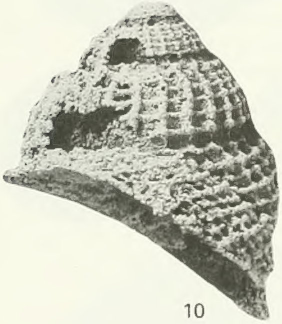
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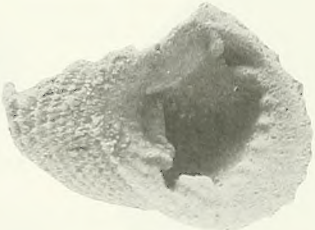
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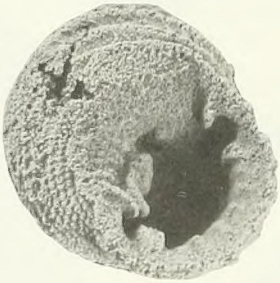
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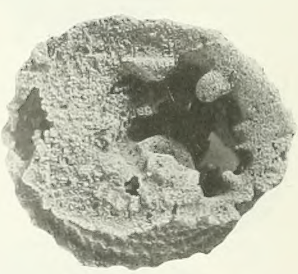
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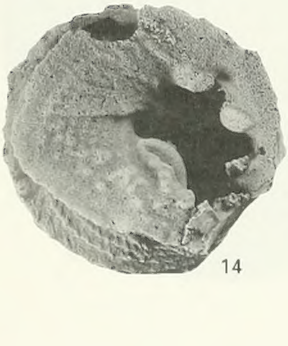
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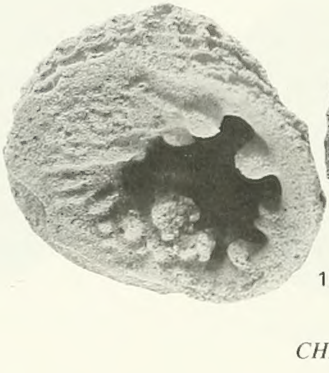
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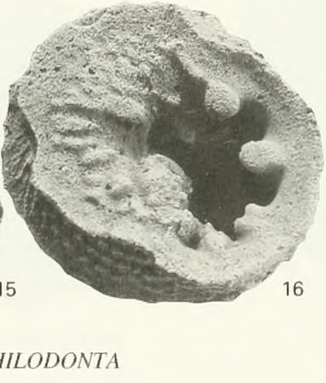
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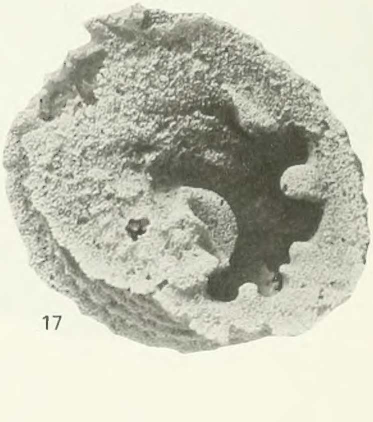
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CHILODONTA

EXPLANATION OF PLATE 6

Figure Page

1–17. ***Chilodonta obliqua*** Sohl, n. sp. 53

1–3. Back, basal, and apertural views (×4) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 28748; USNMNH 468081), showing the open umbilicus of the early stages of growth.

4. Apertural profile view (×4) of a paratype from the same locality (USGS Mesozoic locality 29075; USNMNH 468082).

5. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 29075; USNMNH 468083).

6–8, 15, 16. Apertural, apertural profile, back, oblique-basal, and basal views (×4) of the holotype from the same locality (USGS Mesozoic locality 29088; USNMNH 421478).

9. Apertural profile view (×4) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468084). Only last whorl of specimen is intact. A indicates position of aperture, and arrows indicate line of demarcation between primary and secondary sculpture.

10. Apertural profile view (×3) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468085).

11. Oblique apertural view (×4) of a paratype from the same locality (USGS Mesozoic locality 29075; USNMNH 468086), showing early-mature stage of aperture margin denticulation.

12. Oblique apertural view (×4) of a paratype from the same locality (USGS Mesozoic locality 29075; USNMNH 468087).

13, 17. Oblique basal (×3) and basal (×4) views of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468088).

14. Basal view of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468089).

EXPLANATION OF PLATE 7

Figure Page

1–3, 10. ***Chilodonta jamaicaensis*** Sohl, n. sp. 55

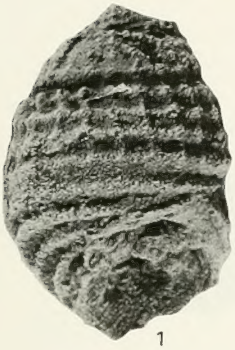
1. Apertural view (×6) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 71 (USGS Mesozoic locality 30000; USNMNH 468099).
2. Apertural profile view (×6) of the holotype from the same locality (USGS Mesozoic locality 30000; USNMNH 468098).

3, 10. Apertural view (×6) and basal view (SEM ×13) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 72 (USGS Mesozoic locality 30009; USNMNH 468100).

4–9, 11–13. ***Chilodonta*** aff. ***C. obliqua*** Sohl 55

4. Apertural view (×6) of an incomplete specimen from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468090).
5. Apertural view (×4) of a specimen from Puerto Rico, Central Aguirre quadrangle, Coamo Formation, at locality 2 (USGS Mesozoic locality 26393; USNMNH 468091).
6. Back view (×6) of a specimen from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468092).
7. Apertural view (×4) of a compressed specimen from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 54 (USGS Mesozoic locality 33371; USNMNH 468093).
8. Apertural view (×6) of a specimen from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468094).
9. Back view (SEM ×16) of a specimen from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 65 (USGS Mesozoic locality 30493; USNMNH 468095).
11. Apical view (SEM ×39) of a specimen from the same locality (USGS Mesozoic locality 30493; USNMNH 468096).

12, 13. Apical views (SEM ×21, ×54) of a specimen from the same locality (USGS Mesozoic locality 30493; USNMNH 468097).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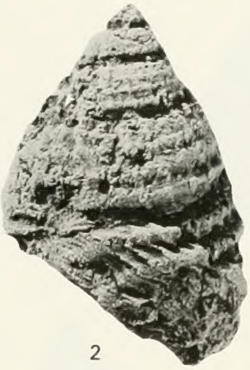
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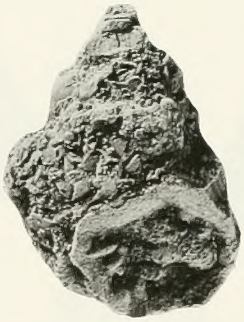
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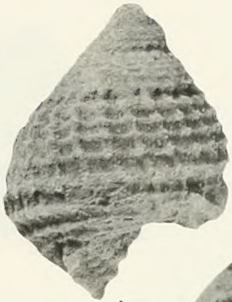
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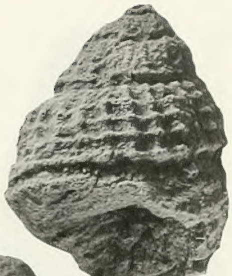
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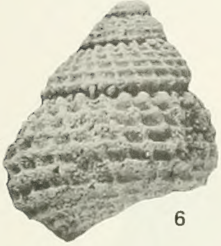
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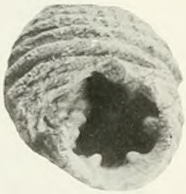
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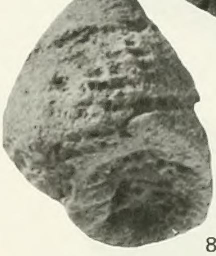
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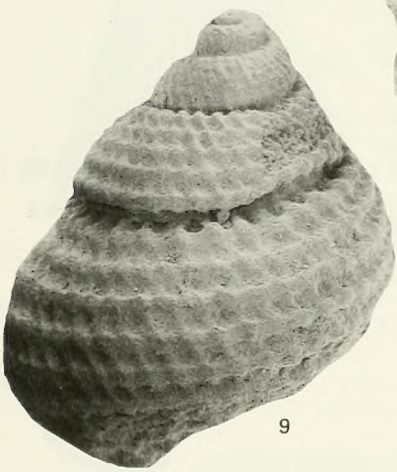
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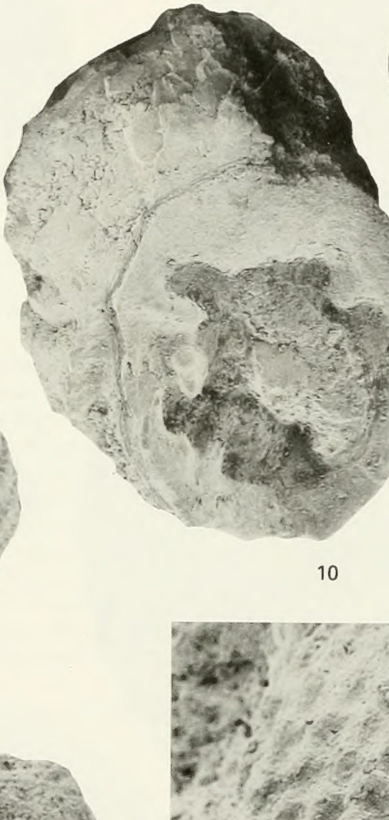
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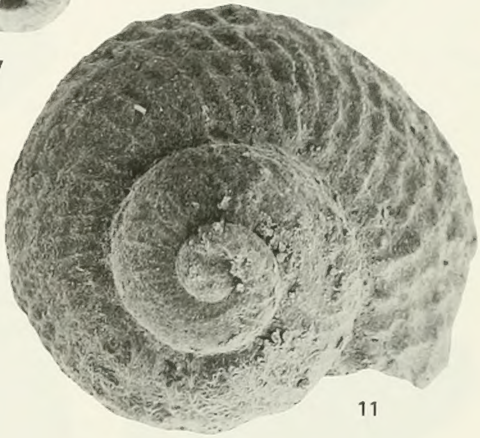
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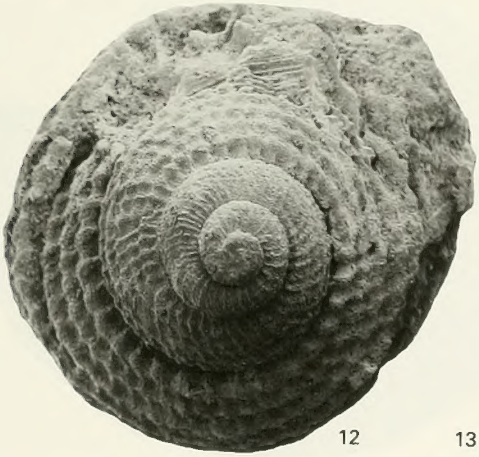
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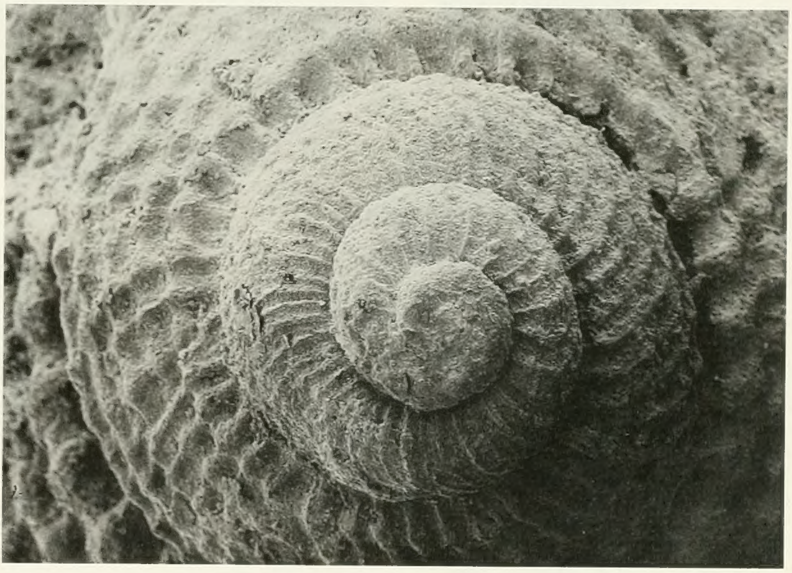
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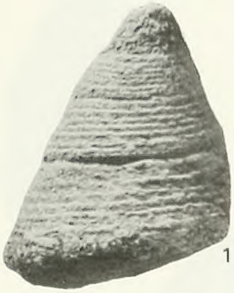
CHILODONTA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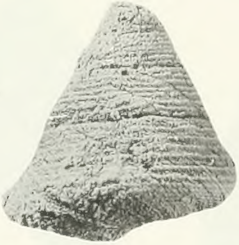
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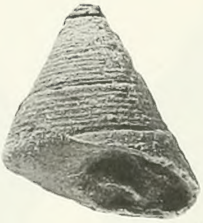
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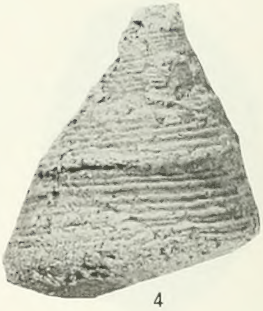
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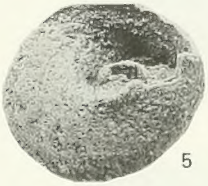
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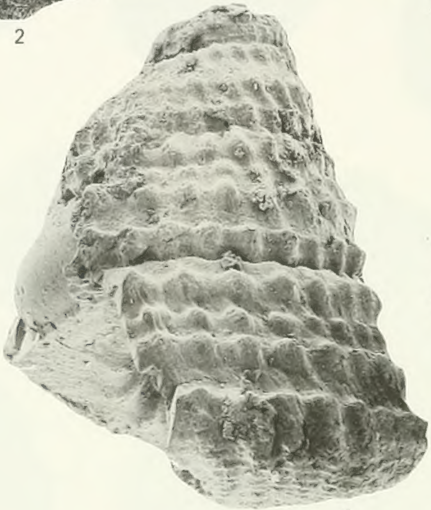
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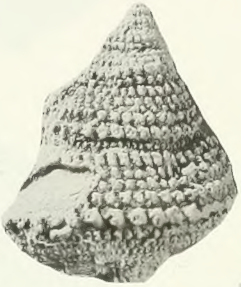
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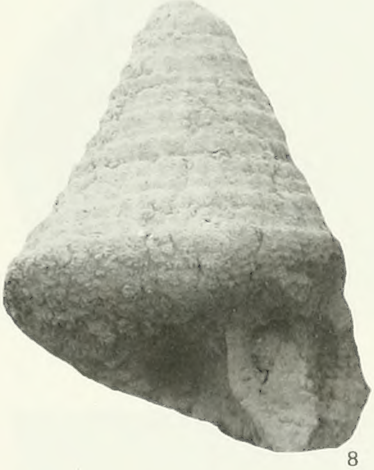
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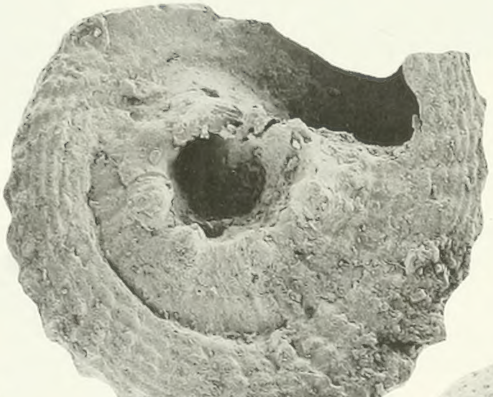
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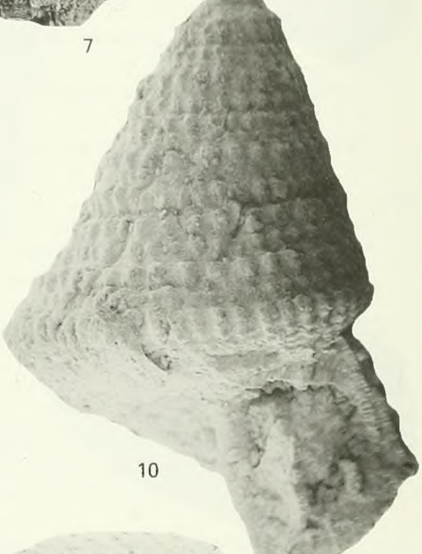
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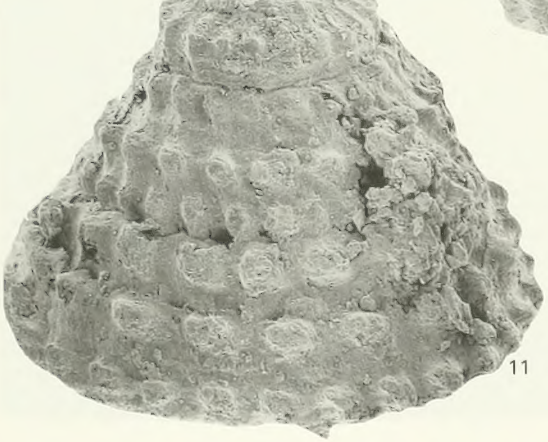
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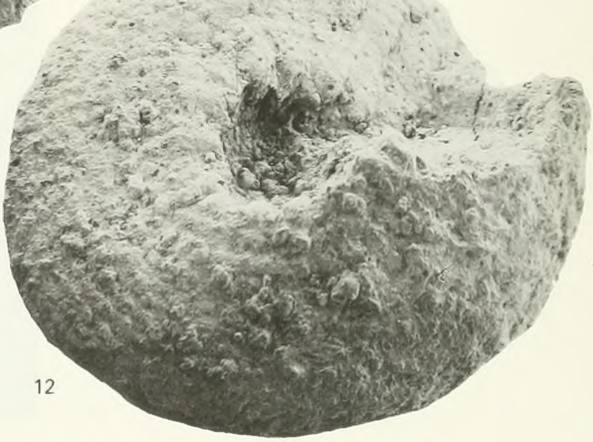
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DISCOTECTUS, *PLANOLATERALUS*/, AND *EUCYCLUS*/

EXPLANATION OF PLATE 8

Figure Page

1–5. ***Discotectus coquiensis*** Sohl, n. sp. 58

1. Back view (×5) of a paratype from Puerto Rico, Central Aguirre quadrangle, Coamo Formation, at locality 2 (USGS Mesozoic locality 26829; USNMNH 468107).

2. Back view (×5) of a paratype from the same locality (USGS Mesozoic locality 26393; USNMNH 468108).

3, 5. Apertural and basal views (×4) of the holotype from the same locality (USGS Mesozoic locality 30358; USNMNH 468106).

4. Back view (×6) of a paratype from the same locality (USGS Mesozoic locality 30358; USNMNH 468109); note inclination of growth line.

6, 8–12. ***Planolateralus? hanoverensis*** Sohl, n. sp. 56

6. Side view (SEM ×32) of a paratype from Jamaica, St. Anns Great River inlier, Windsor Shale, at locality 23 (USGS Mesozoic locality 29956; USNMNH 468103).

8, 10. Inclined apertural and apertural views (SEM ×17, ×18) of the holotype from Jamaica, Lucea inlier, Askenish Formation, at locality 67 (USGS Mesozoic locality 30425; USNMNH 468102).

9, 11. Basal and inclined back views (SEM ×30, ×35) of a paratype from Jamaica, St. Anns Great River inlier, Windsor Shale, at locality 23 (USGS Mesozoic locality 29956; USNMNH 468104). Figure 9 shows a fracture on the basal surface caused by compression of the specimen.

12. Basal view of a paratype (SEM ×29) from Jamaica, Lucea inlier, Askenish Formation, at locality 66 (USGS Mesozoic locality 29902; USNMNH 468105).

7. ***Eucyclus?*** sp. 53

Back view (×3) of a specimen from Jamaica, Lucea inlier, Askenish Formation, at locality 66 (USGS Mesozoic locality 29902; USNMNH 468080).

EXPLANATION OF PLATE 9

Figure | Page

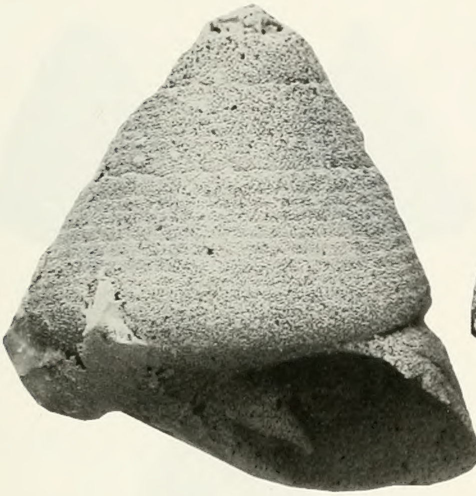
1–3, 5. ***Discotectus*** sp. 64

1. Apertural view (SEM ×15) of a specimen from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468112).
2. Profile view (SEM ×16) of a specimen from the same locality (USGS Mesozoic locality 29088; USNMNH 468113).
3. Back view (SEM ×16) of a specimen from the same locality (USGS Mesozoic locality 29088; USNMNH 468114).
5. Back view (SEM ×16) of a specimen from the same locality (USGS Mesozoic locality 29088; USNMNH 468115).

4, 6–8. ***Discotectus coquiensis*** Sohl, n. sp. 58

4, 6. Basal view (SEM ×14) and enlargement of sculpture (SEM ×25) of a paratype from Puerto Rico, Central Aguirre quadrangle, Coamo Formation, at locality 2 (USGS Mesozoic locality 30358; USNMNH 468110).

7, 8. Enlargement of sculpture (SEM ×33) and apertural view (SEM ×16) of a paratype from the same locality (USGS Mesozoic locality 30358; USNMNH 468111).



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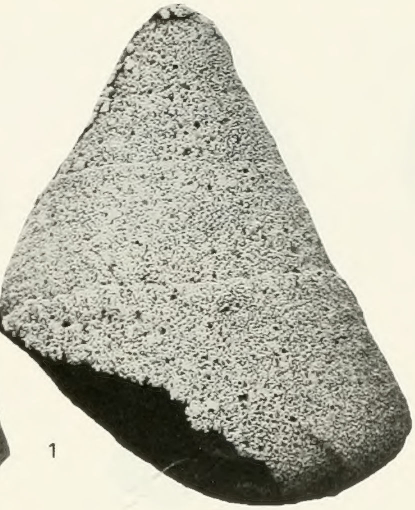

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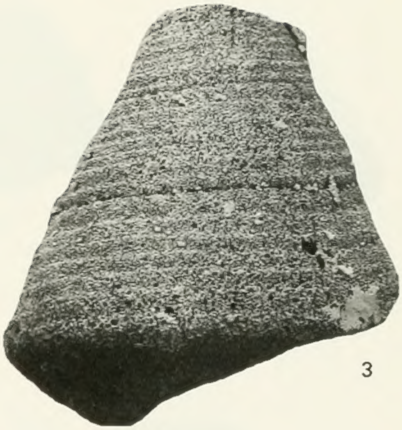

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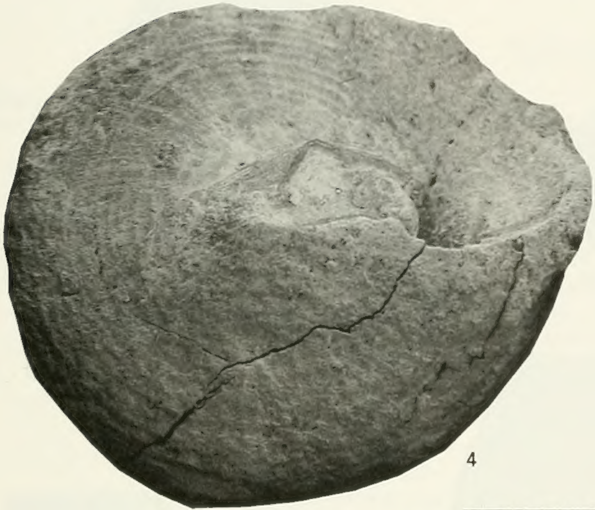

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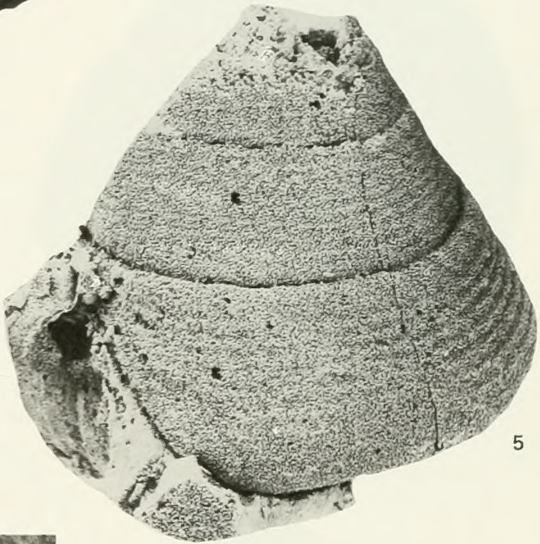

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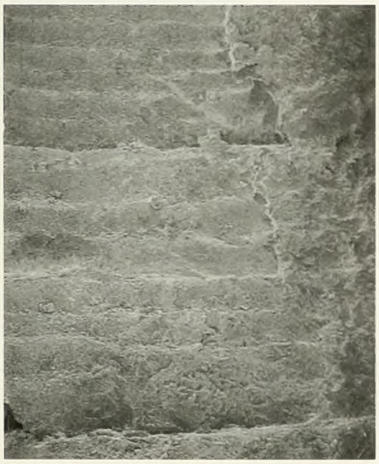

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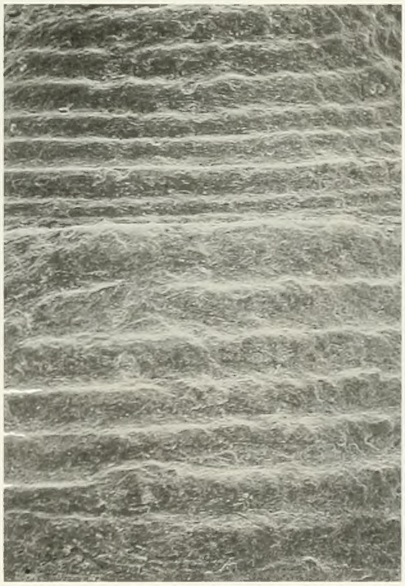

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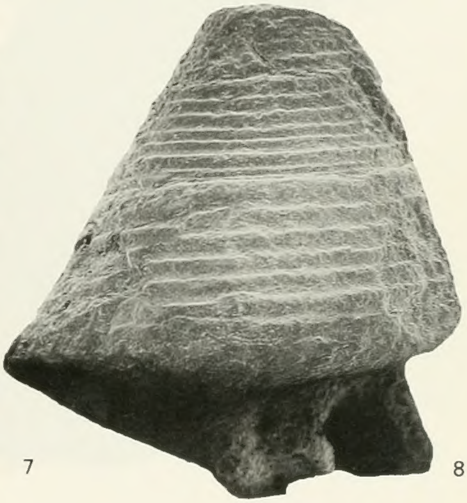

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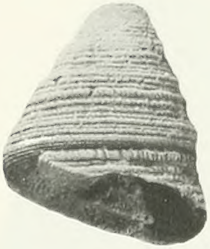
DISCOTECTUS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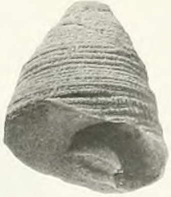
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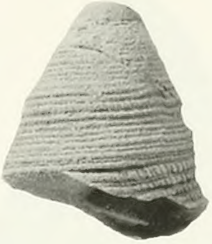
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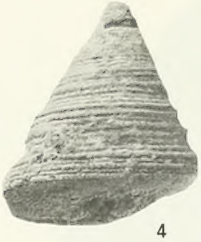
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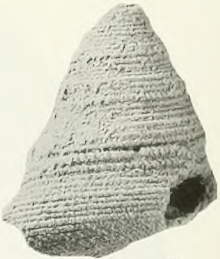
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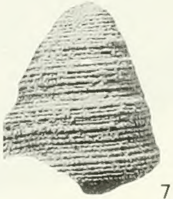
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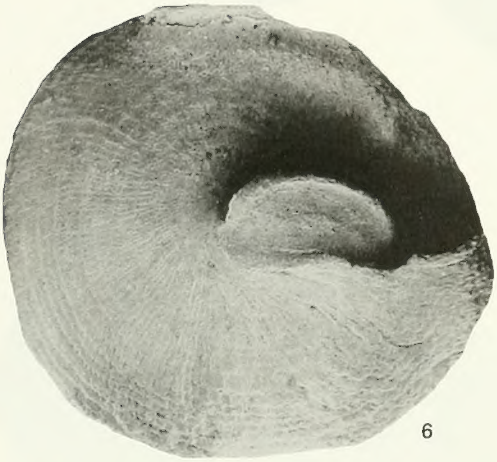
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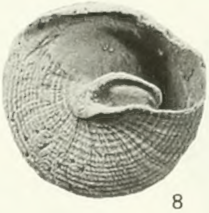
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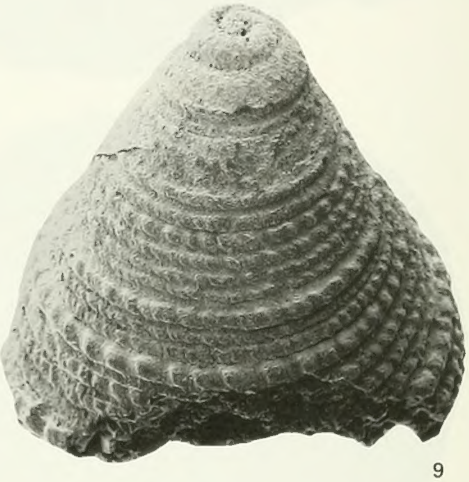
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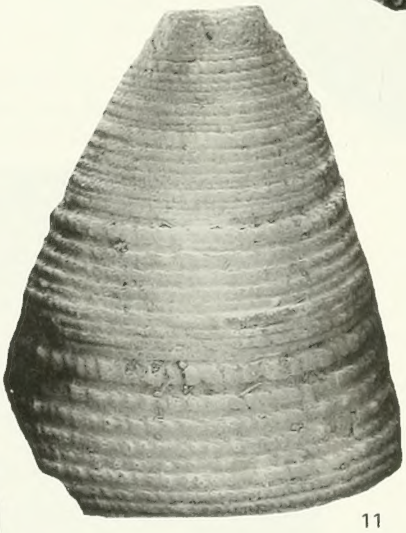
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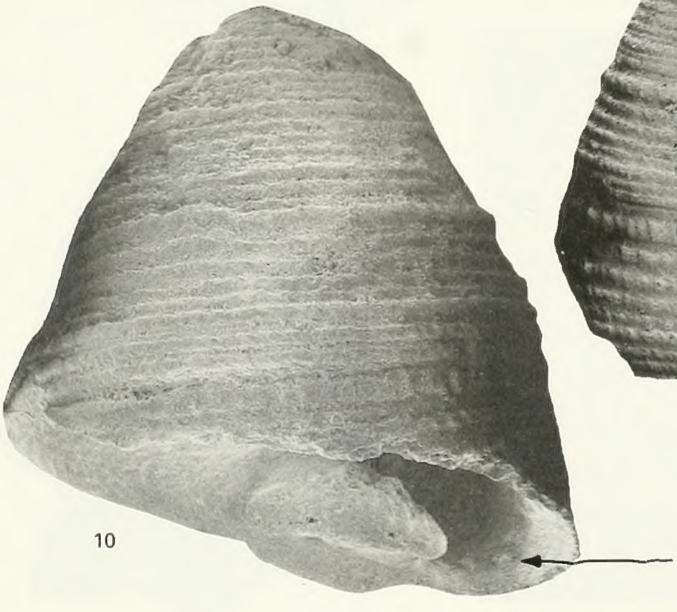
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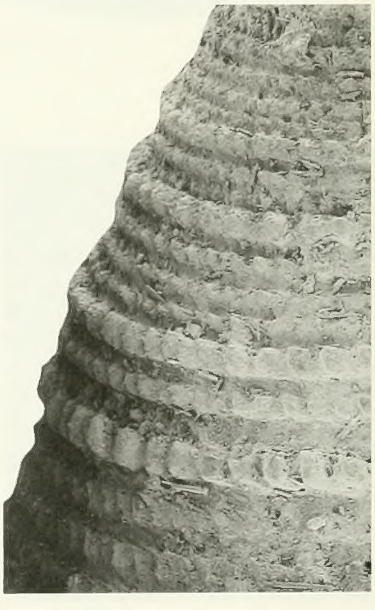
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DISCOTECTUS

EXPLANATION OF PLATE 10

Figure — Page

1–12. ***Discotectus barranquitasensis*** Sohl, n. sp. 59

1. Apertural view (×5) of the holotype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 4 (USGS Mesozoic locality 26802; USNMNH 468116).

2, 3. Inclined apertural view (×4) and apertural profile view (×5) of a paratype from the same locality (USGS Mesozoic locality 26802; USNMNH 468117).

4. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 26802; USNMNH 468118).

5. Back view (×5) of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 5 (USGS Mesozoic locality 31489; USNMNH 468119).

6. Basal view (SEM ×10) of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 4 (USGS Mesozoic locality 26802; USNMNH 468120).

7. Back view (×4) of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 5 (USGS Mesozoic locality 31489; USNMNH 468121).

8, 10. Basal view (×5) and apertural view (SEM ×13) of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 4 (USGS Mesozoic locality 26802; USNMNH 468122); arrow on figure 10 points to node inside of outer lip.

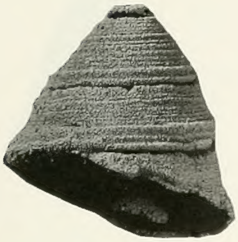
9. Apical view (SEM ×23) of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 5 (USGS Mesozoic locality 31489; USNMNH 468123).

11. Back view (SEM ×10) of a paratype from the same locality (USGS Mesozoic locality 31489; USNMNH 468124).

12. Detail of sculpture (SEM ×26) of a paratype from the same locality (USGS Mesozoic locality 31489; USNMNH 468125).

EXPLANATION OF PLATE 11

Figure		Page
1–6.	***Discotectus cyrtoconus*** Sohl, n. sp.	60
1, 2.	Apertural profile and basal views (×4) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468133).	
3, 4, 6.	Back (×4), apertural profile (×4), and apertural (×5) views of the holotype from the same locality (USGS Mesozoic locality 29088; USNMNH 468132).	
5.	Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 29088; USNMNH 468134).	
7–13.	***Discotectus gelaberti*** Sohl, n. sp.	60
7.	Apertural view (SEM ×13) of a paratype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468127).	
8, 10.	Angled back (SEM ×18) and back (SEM ×21) views of a paratype from the same locality (USGS Mesozoic locality 29365; USNMNH 468128).	
9.	Back view (SEM ×18) of a paratype from the same locality (USGS Mesozoic locality 29365; USNMNH 468129).	
11.	Basal view (SEM ×18) of a paratype from the same locality (USGS Mesozoic locality 29365; USNMNH 468130).	
12.	Back view (SEM ×5) of a paratype from the same locality (USGS Mesozoic locality 29365; USNMNH 468131).	
13.	Back view (SEM ×14) of the holotype from the same locality (USGS Mesozoic locality 29365; USNMNH 468126).	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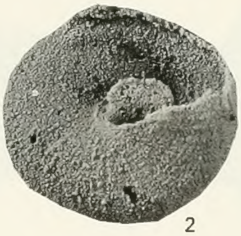
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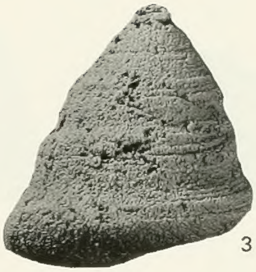
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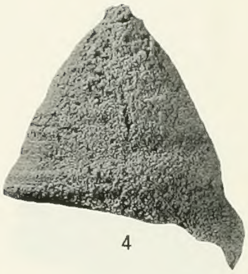
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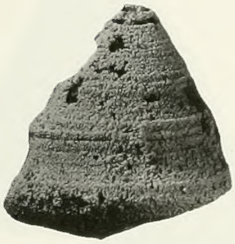
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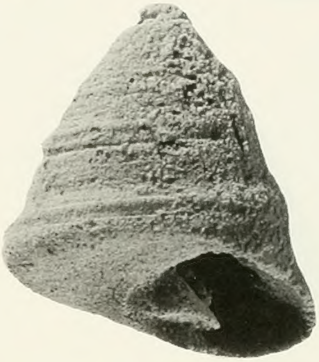
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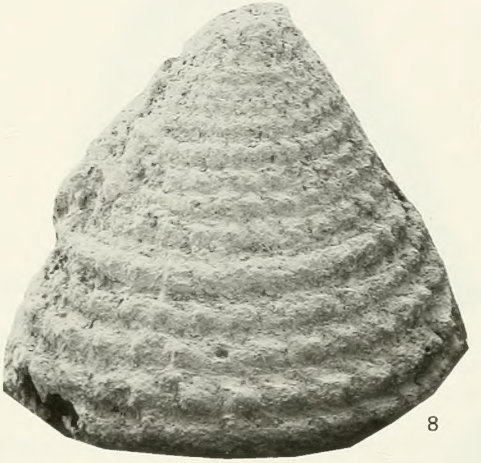
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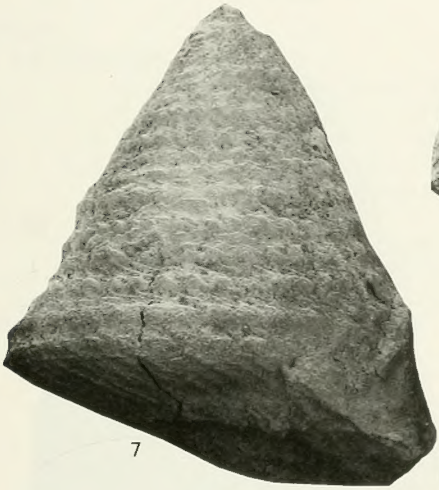
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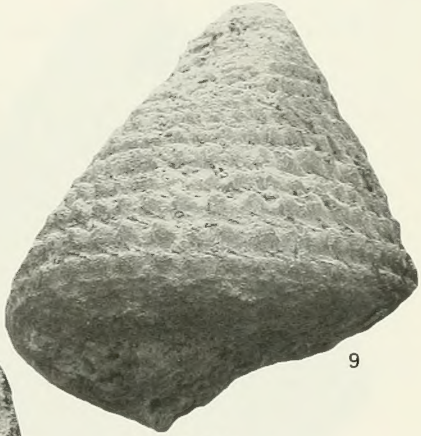
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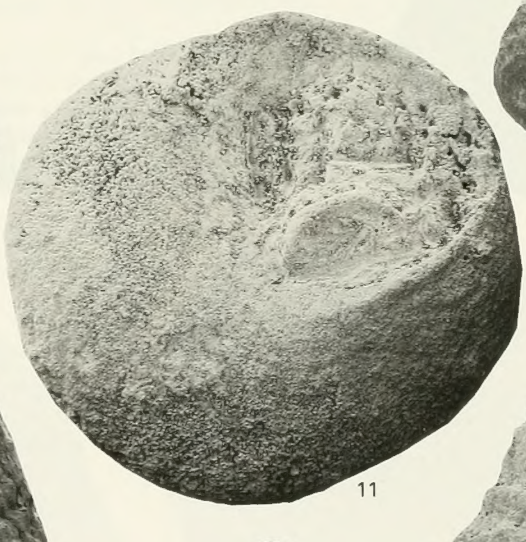
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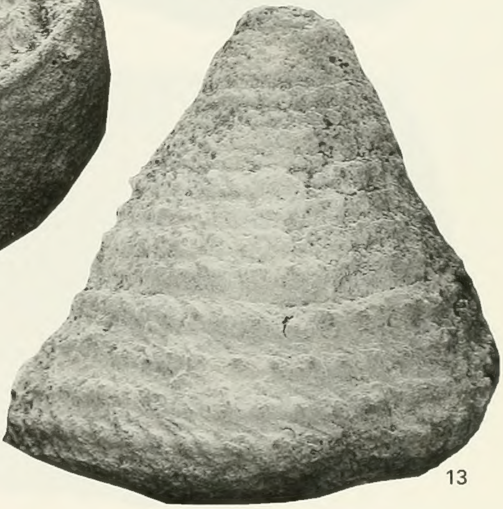
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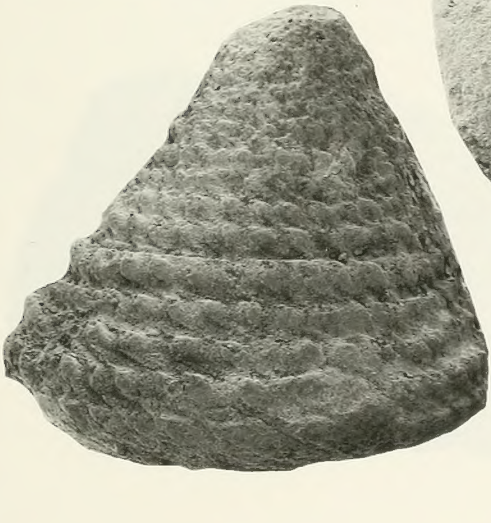
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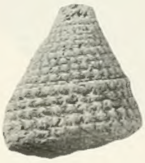
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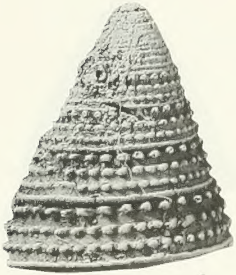
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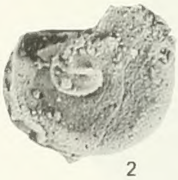
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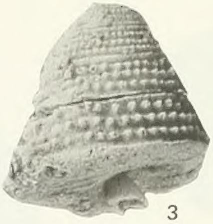
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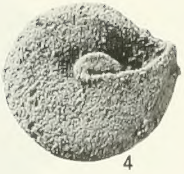
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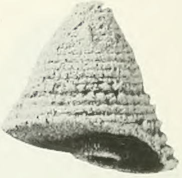
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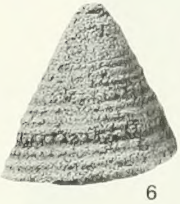
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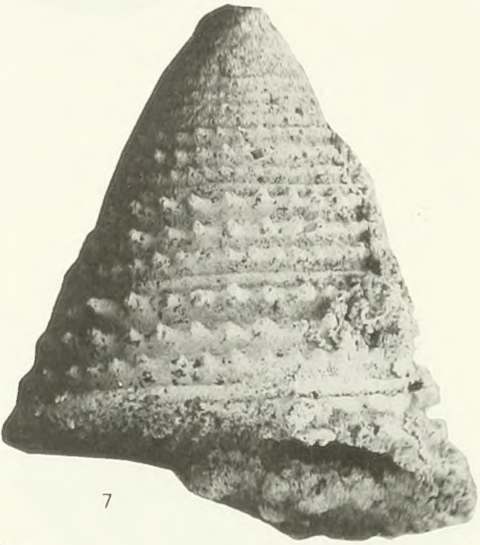
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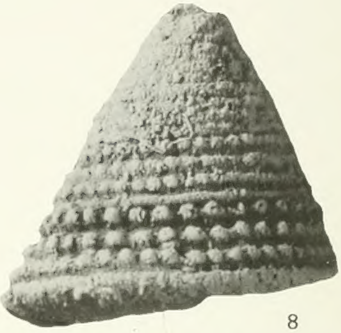
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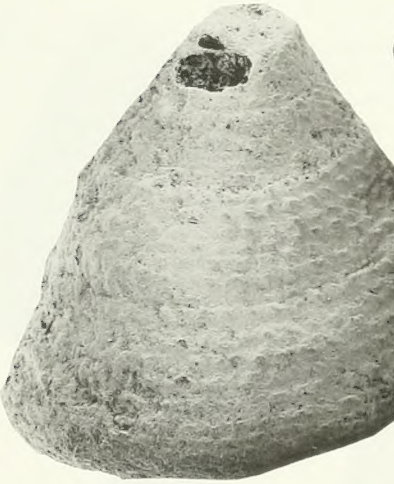
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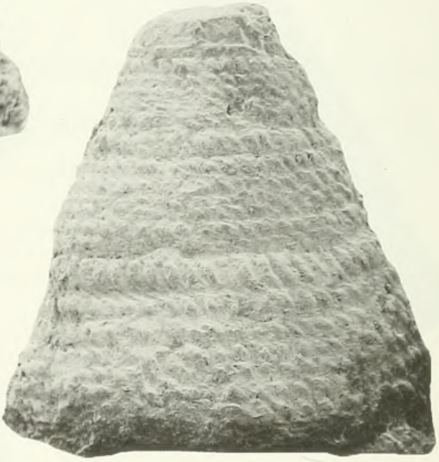
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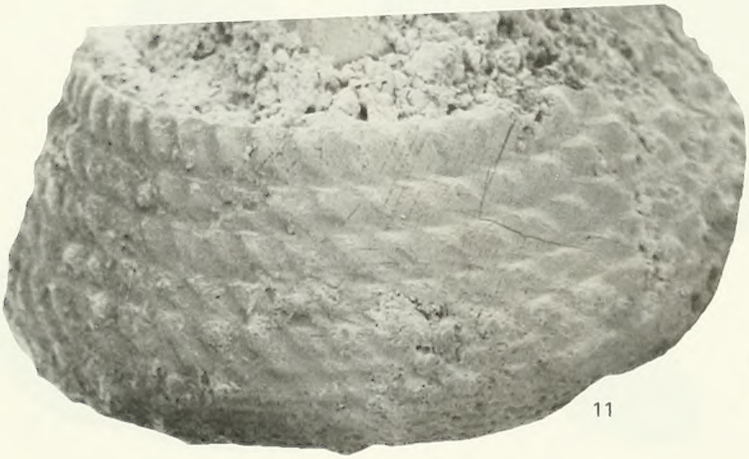
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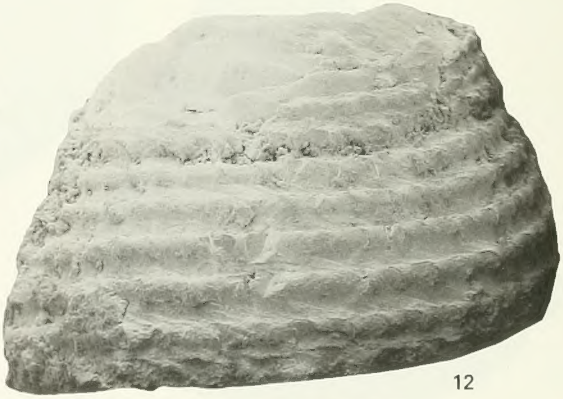
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DISCOTECTUS

EXPLANATION OF PLATE 12

Figure Page

1–8. ***Discotectus scotti*** Sohl, n. sp.. 61

1. Back view (×4) of a paratype from Puerto Rico, San German quadrangle, Sabana Grande Formation, at locality 17 (USGS Mesozoic locality 30343; USNMNH 468136).

2, 3. Basal and back views (×4) of a paratype from the same locality (USGS Mesozoic locality 30343; USNMNH 468137).

4, 5, 8. Basal and apertural views (×5) and back view (×10) of a paratype from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 28664; USNMNH 468138); note rounded nodes on spirals of body whorl.

6. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 28664; USNMNH 468139).

7. Apertural view (SEM ×11) of the holotype from Puerto Rico, San German quadrangle, Sabana Grande Formation, at locality 17 (USGS Mesozoic locality 30343; USNMNH 468135).

9–12. ***Discotectus crebrinodosus*** Sohl, n. sp. 62

9. Back view (SEM ×17) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 72 (USGS Mesozoic locality 30009; USNMNH 468141).

10. Apertural view (SEM ×19) of the holotype from the same locality (USGS Mesozoic locality 30009; USNMNH 468140).

11. View (SEM ×36) of an incomplete paratype from the same locality (USGS Mesozoic locality 30009; USNMNH 468142).

12. Back view (SEM ×25) of an incomplete paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 69 (USGS Mesozoic locality 30429; USNMNH 468143).

EXPLANATION OF PLATE 13

Figure		Page
1–10.	***Discotectus zansi*** Sohl, n. sp.	62

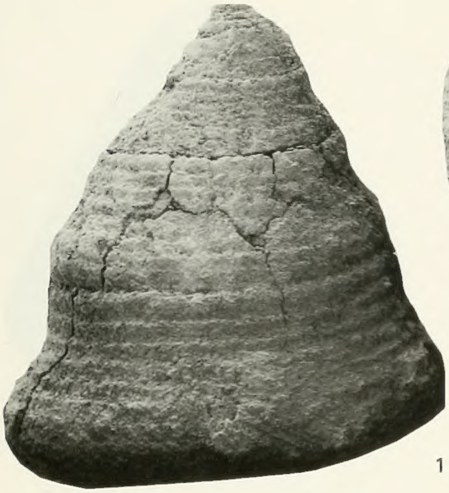
1. Back view of a paratype (SEM ×16) from Jamaica, St. Anns Great River inlier, St. Anns Great River Formation, at locality 27 (USGS Mesozoic locality 30502; USNMNH 468145).
2. Basal view (SEM ×17) of a paratype from the same locality, showing details of sculpture (USGS Mesozoic locality 30502; USNMNH 468146).
3. Back view (×5) of a paratype from the same locality (USGS Mesozoic locality 30502; USNMNH 468147).

4, 5. Basal and back views (×5) of the holotype from the same locality (USGS Mesozoic locality 30502; USNMNH 468144).

6. Back view (SEM ×16) of a paratype from the same locality (USGS Mesozoic locality 30502; USNMNH 468148).

7, 8, 10. Detail view (SEM ×40), back view (SEM ×12), and view (SEM ×24) of body whorl of a paratype from the same locality (USGS Mesozoic locality 30502; USNMNH 468149). Arrows on figures 7 and 10 indicate to corresponding points.

9. Back view (SEM ×19) of the body whorl of a paratype from the same locality (USGS Mesozoic locality 30502; USNMNH 468150).



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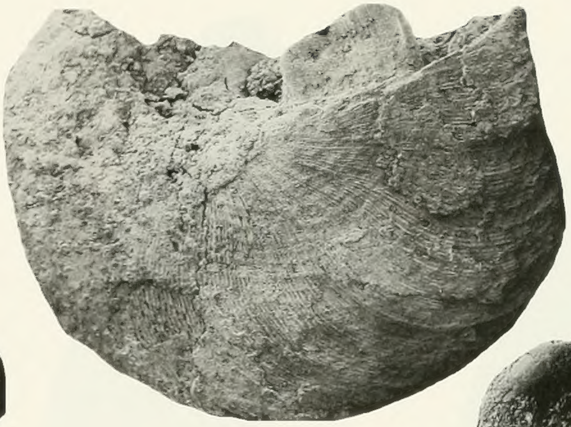

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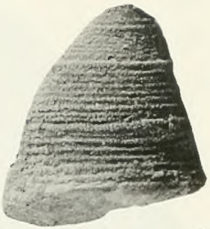

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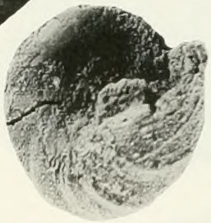

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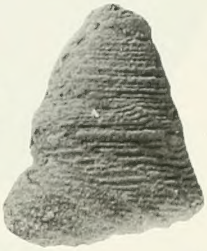

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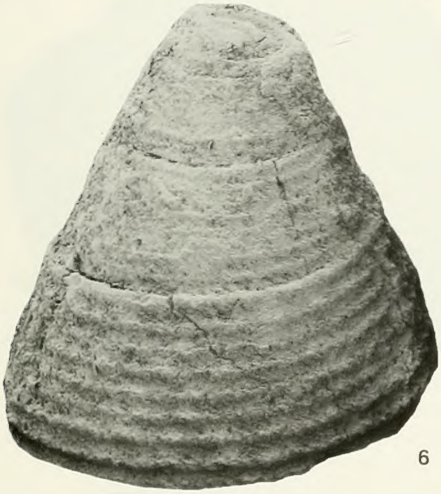

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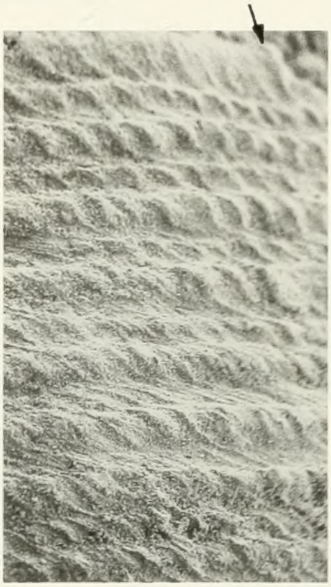

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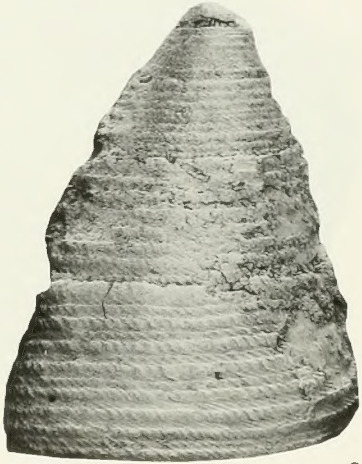

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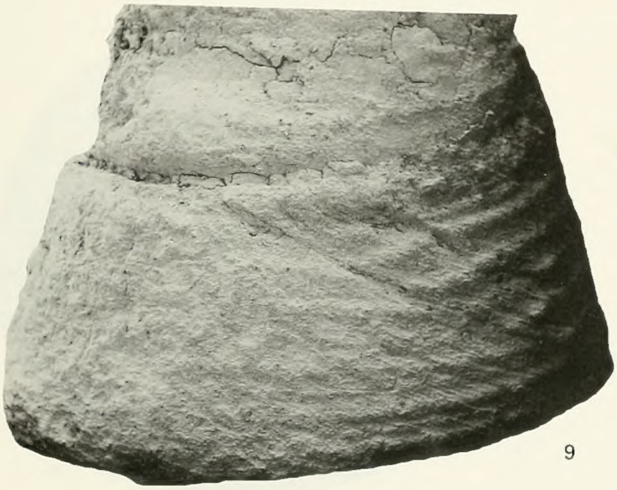

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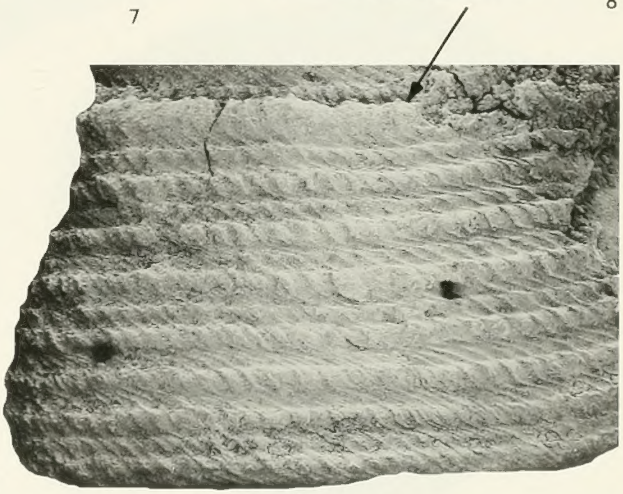

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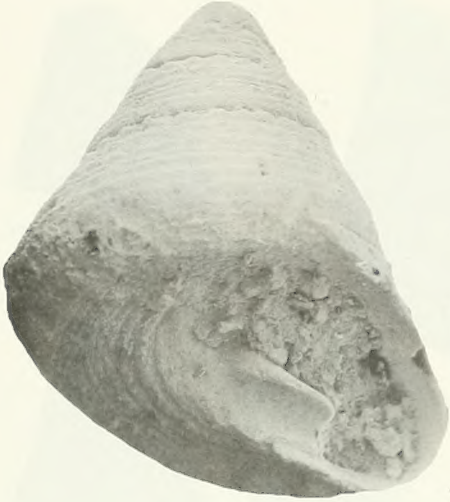
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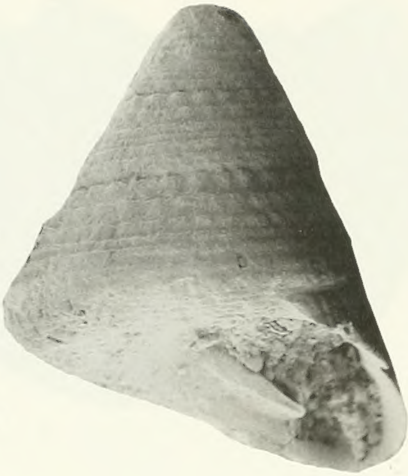
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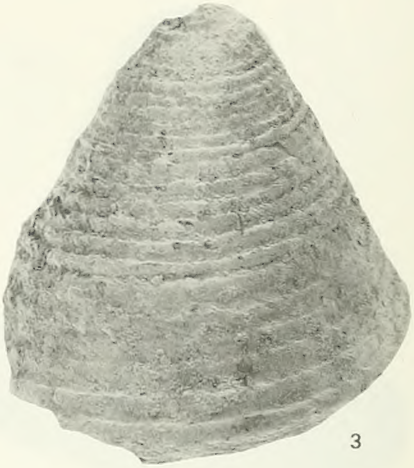
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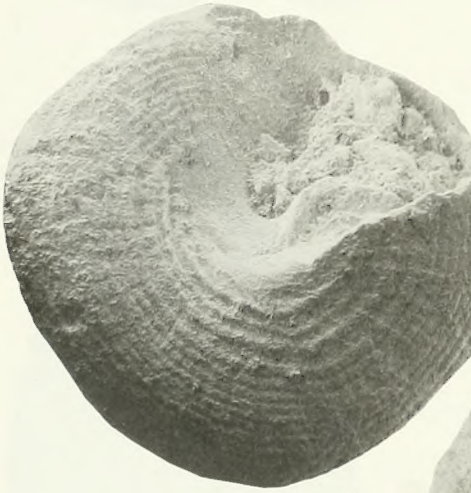
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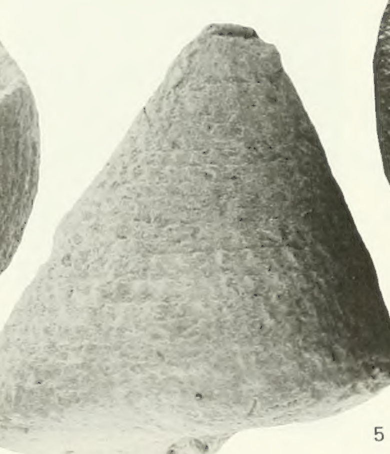
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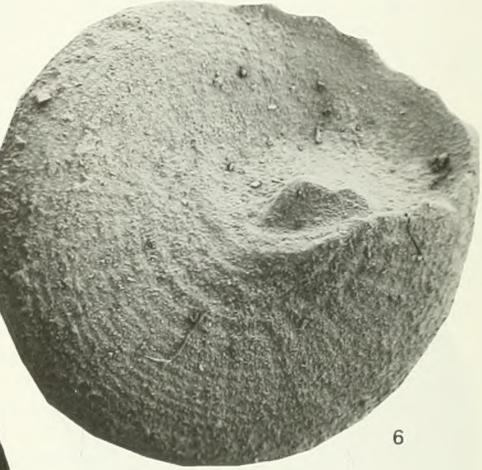
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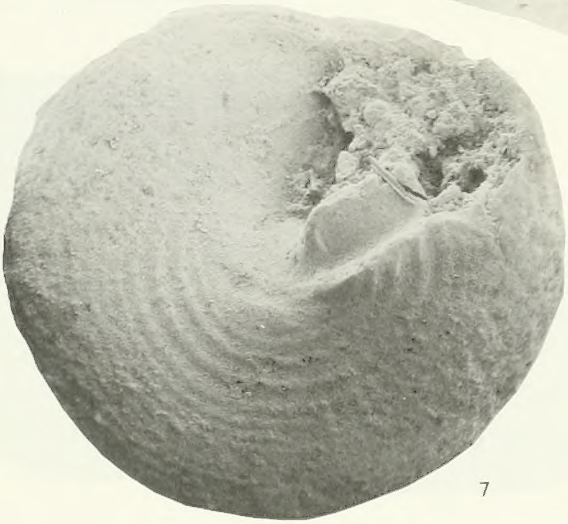
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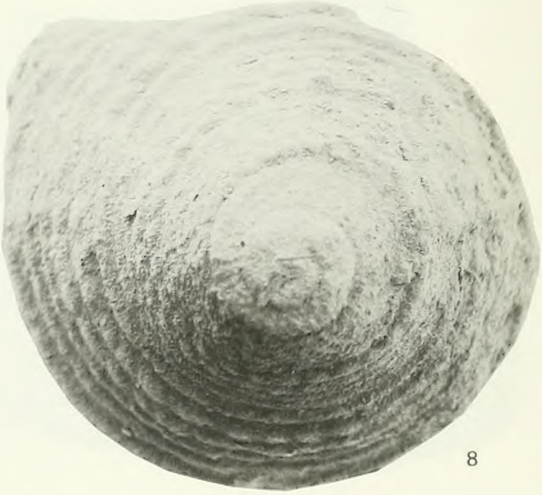
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DISCOTECTUS

EXPLANATION OF PLATE 14

Figure Page

1–8. ***Discotectus marchmontensis*** Sohl, n. sp. 63

1, 2. Inclined apertural and apertural views (SEM ×13) of the holotype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 52 (USGS Mesozoic locality 30030; USNMNH 468151).

3. Back view (SEM ×19) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 61 (USGS Mesozoic locality 30482; USNMNH 468152). See also Plate 17, figure 11.

4. Basal view (SEM ×17) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 52 (USGS Mesozoic locality 30030; USNMNH 468153).

5. Back view (SEM ×14) of a paratype from Jamaica, Central inlier, Guinea Corn Formation, at locality 43 USGS Mesozoic locality 30040; USNMNH 468154).

6. Basal view (SEM ×21) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 57 (USGS Mesozoic locality 30466; USNMNH 468155).

7. Basal view (SEM ×16) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 57 (USGS Mesozoic locality 30466; USNMNH 468156).

8. Apical view (SEM ×29) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 63 (USGS Mesozoic locality 31367; USNMNH 468157).

EXPLANATION OF PLATE 15

Figure		Page
1–9.	***Denticulabrum laevigatum*** Sohl, n. sp..	65

1. Apical view (SEM ×78) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 61 (USGS Mesozoic locality 30482; USNMNH 468159). Note the transverse ribbing on the early teloconch.

2, 3, 6. Apertural, back, and basal views (×5) of the holotype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 59 (USGS Mesozoic locality 30471; USNMNH 468158).

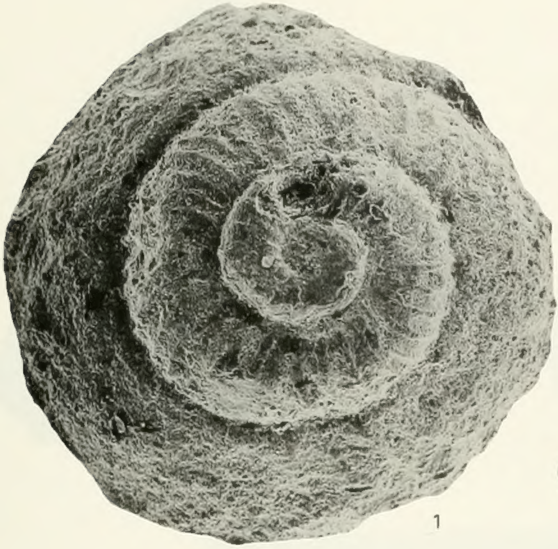
4. Back view (SEM ×12) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 58 (USGS Mesozoic locality 30467; USNMNH 468160).

5. Apertural detail (SEM ×18) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 61 (USGS Mesozoic locality 30482; USNMNH 468161). Note development at parietal plait.

7. Basal view (SEM ×14) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 59 (USGS Mesozoic locality 30471; USNMNH 468162).

8. Basal view (SEM ×15) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 64 (USGS Mesozoic locality 30491; USNMNH 468163).

9. Detail of spire (SEM ×94) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 51 (USGS Mesozoic locality 30027; USNMNH 468164).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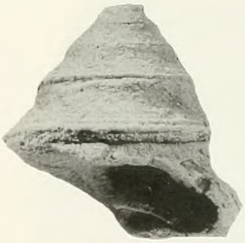
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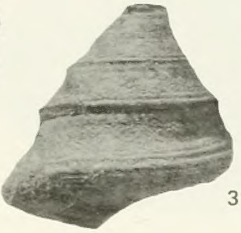
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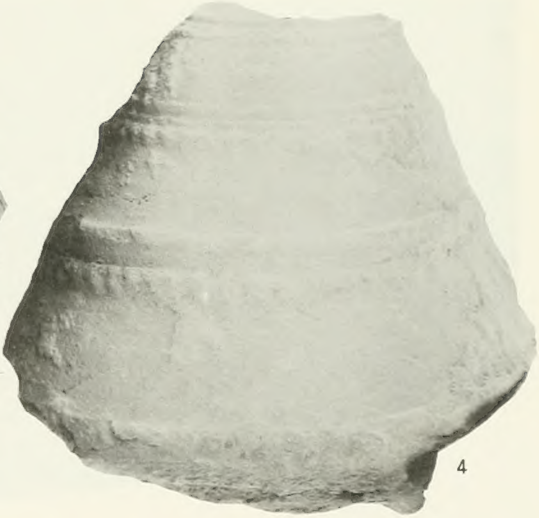
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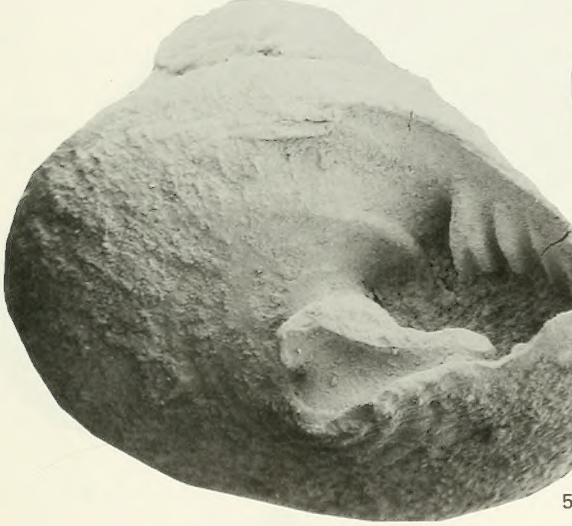
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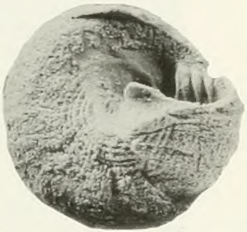
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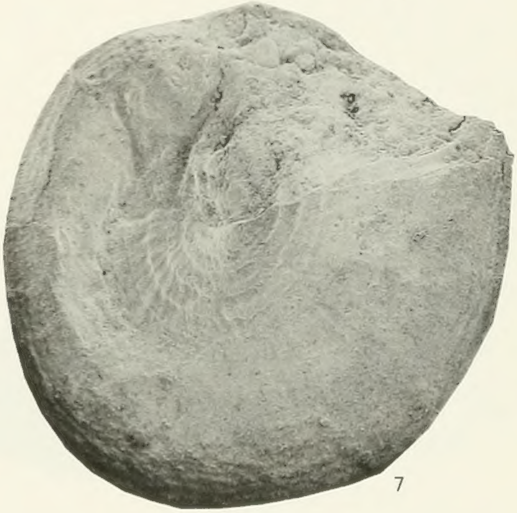
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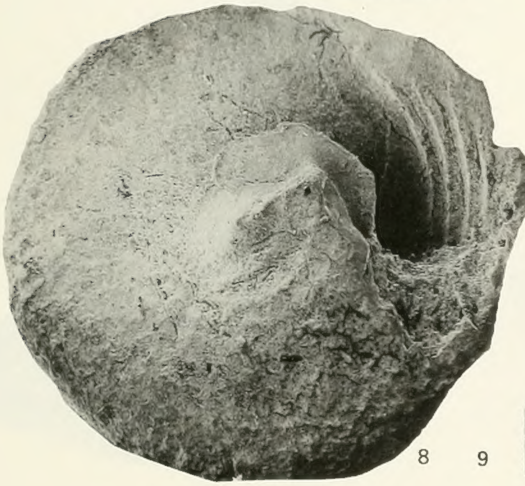
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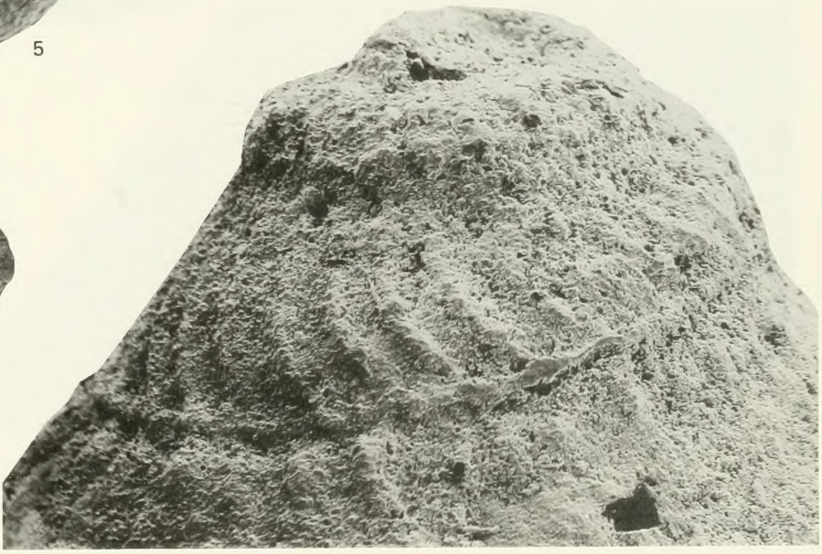
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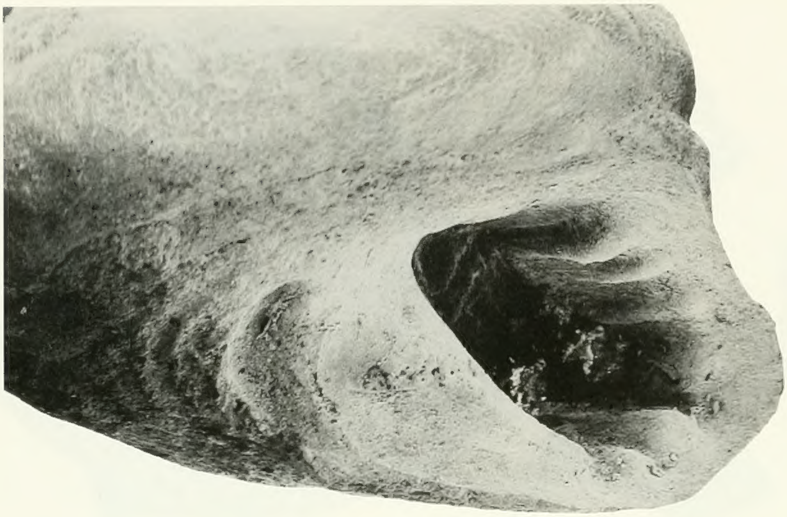
DENTICULABRUM



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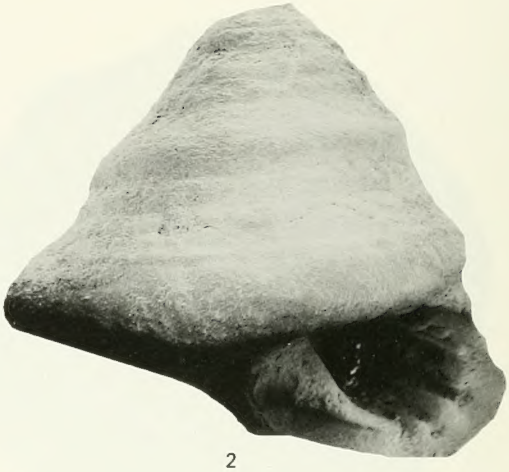

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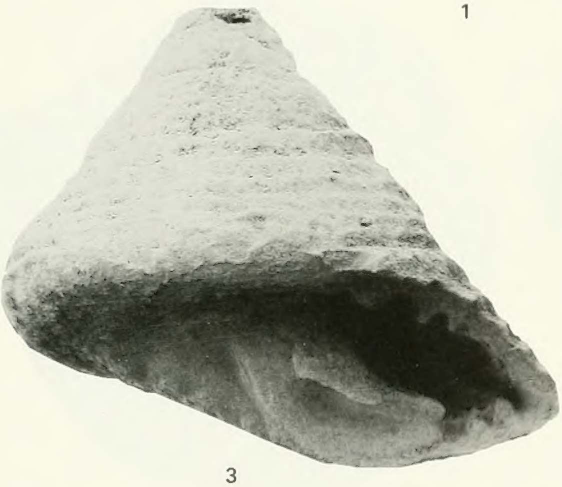

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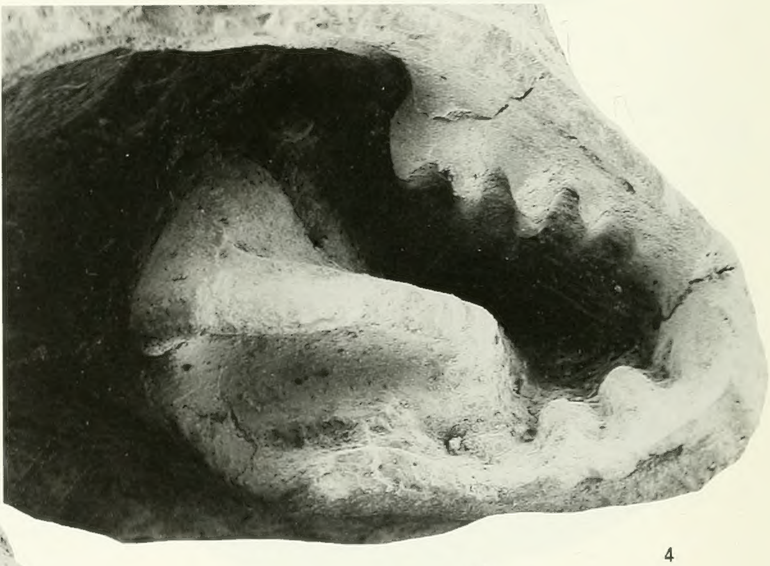

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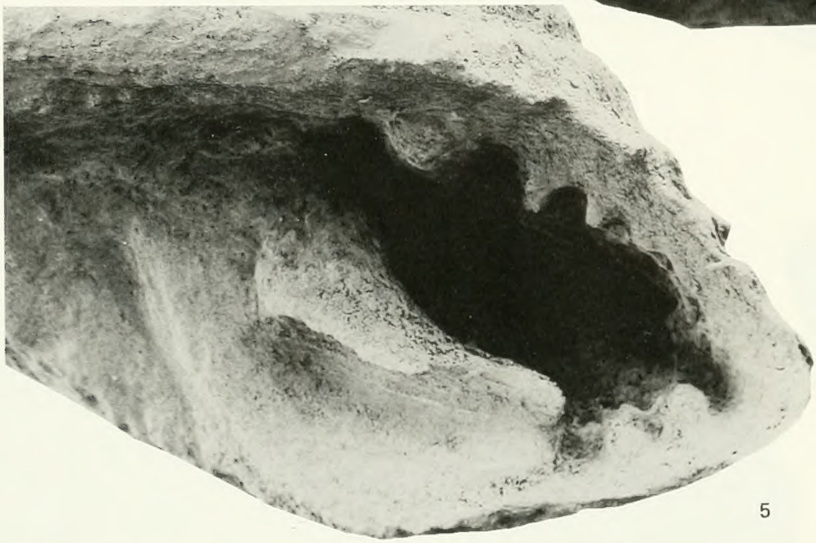

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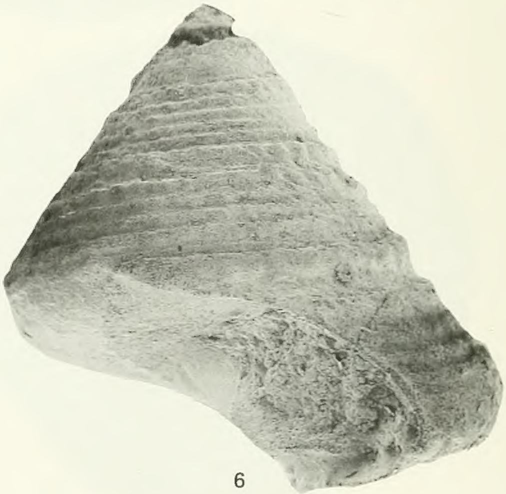

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DENTICULABRUM

Explanation of Plate 16

Figure Page

1–3, 5, 6. ***Denticulabrum duckettsensis*** Sohl, n. sp. 66

1, 2. Detailed view (SEM ×23) of aperture and apertural view (SEM ×14) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 51 (USGS Mesozoic locality 29925; USNMNH 468167).

3, 5. Apertural view (SEM ×19) and detail of aperture (SEM ×40) of the holotype from the same locality (USGS Mesozoic locality 30027; USNMNH 468166).

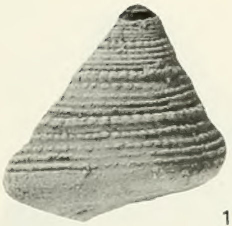
6. Apertural profile view (SEM ×18) of a paratype from the same locality (USGS Mesozoic locality 30027; USNMNH 468168).

4. ***Denticulabrum laevigatum*** Sohl, n. sp. 65

Detail of aperture (SEM ×26) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 59 (USGS Mesozoic locality 30471; USNMNH 468165).

EXPLANATION OF PLATE 17

Figure		Page
1–10.	***Denticulabrum duckettsensis*** Sohl, n. sp.	66
	1. Back view (×5) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 58 (USGS Mesozoic locality 30467; USNMNH 468169).	
	2–4. Basal, apertural, and back views (×5) of a paratype from the same locality (USGS Mesozoic locality 30467; USNMNH 468170).	
	5. Basal view (×5) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 51 (USGS Mesozoic locality 29925; USNMNH 468171). Note sinuosity in profile of basal lip of aperture.	
	6. Back view (SEM ×21) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 58 (USGS Mesozoic locality 30467; USNMNH 468172).	
	7. Back view (×6) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 51 (USGS Mesozoic locality 30027; USNMNH 468173).	
	8. Apertural view (SEM ×18) of a paratype from the same locality (USGS Mesozoic locality 29925; USNMNH 468174).	
	9. Apical view (SEM ×47) of a paratype from the same locality (USGS Mesozoic locality 29925; USNMNH 468175).	
	10. Basal view (SEM ×19) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 58 (USGS Mesozoic locality 30467; USNMNH 468176).	
11.	***Discotectus marchmontensis*** Sohl, n. sp.	63
	View of apex (SEM ×56) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 61 (USGS Mesozoic locality 30482; USNMNH 468152). Apex of same specimen shown on Plate 14, figure 3. Contrast with early stage shell development of Denticulabrum duckettsensis shown on figure 9 of this plate.	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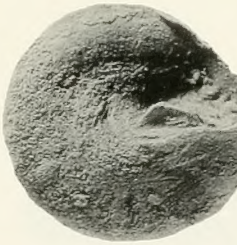
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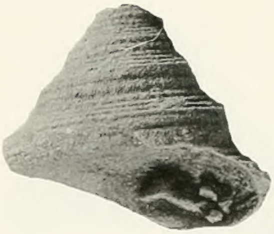
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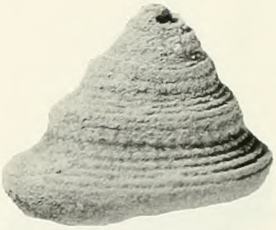
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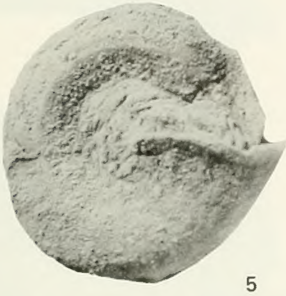
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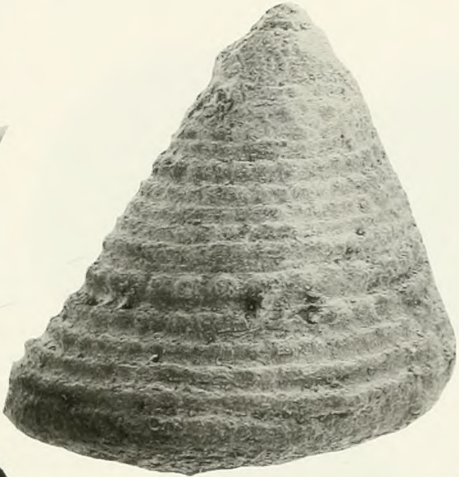
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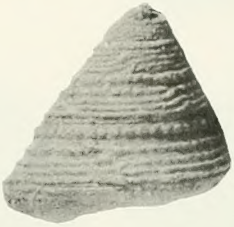
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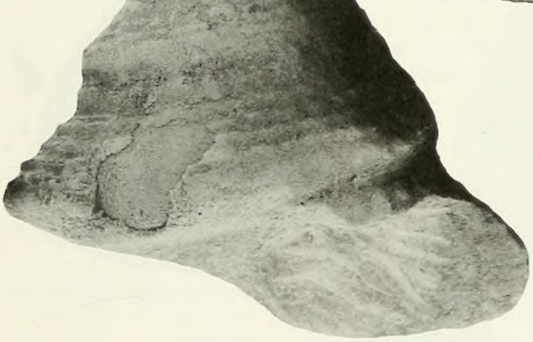
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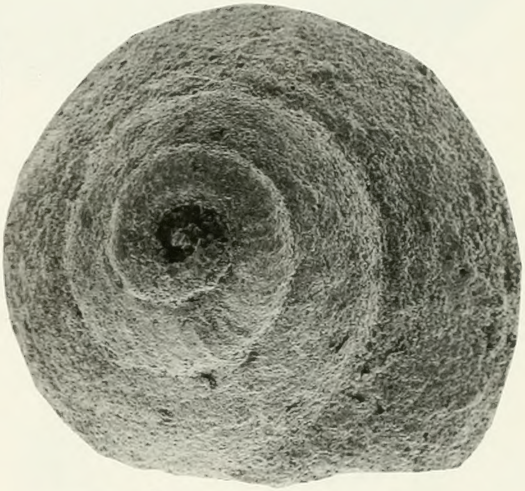
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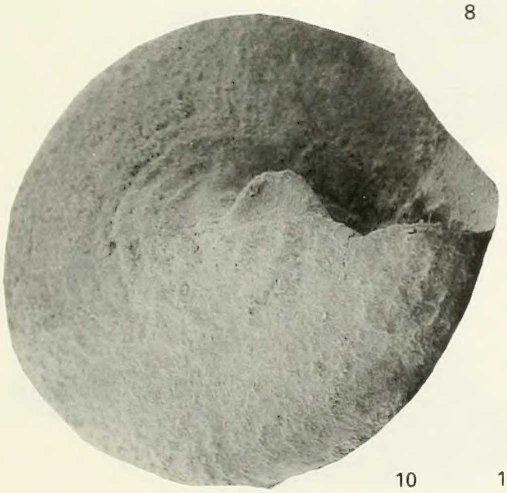
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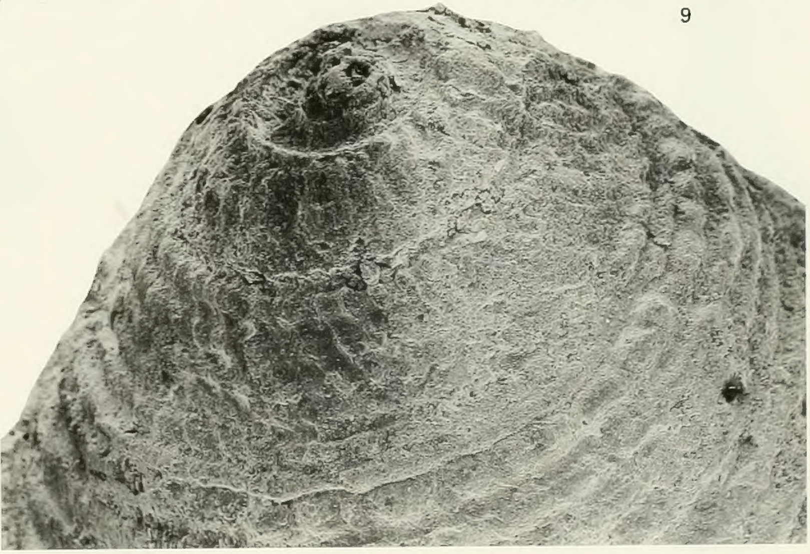
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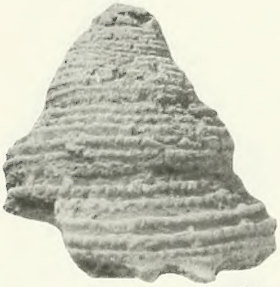
DENTICULABRUM AND *DISCOTECTUS*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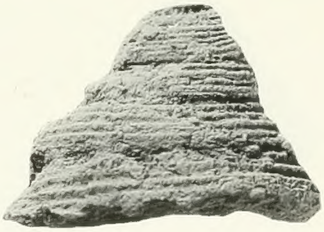
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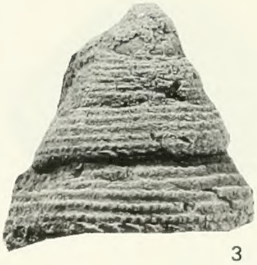
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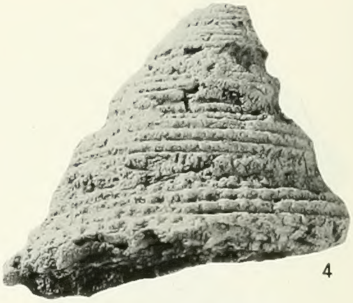
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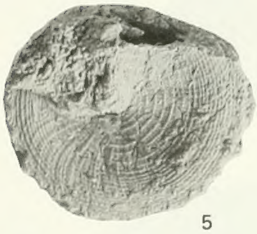
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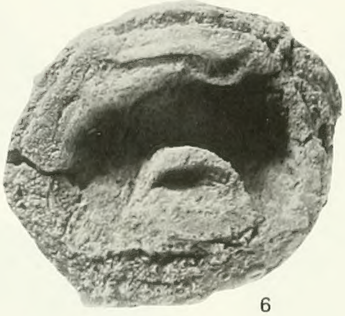
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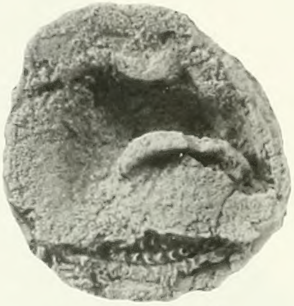
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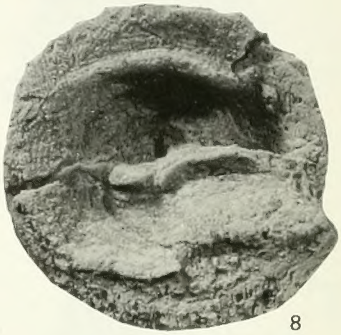
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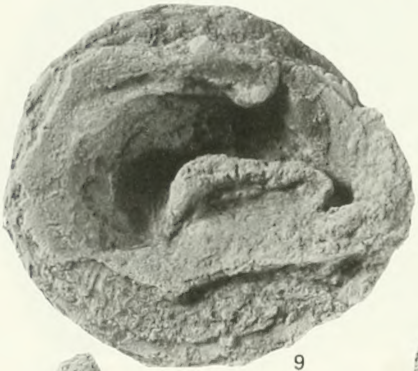
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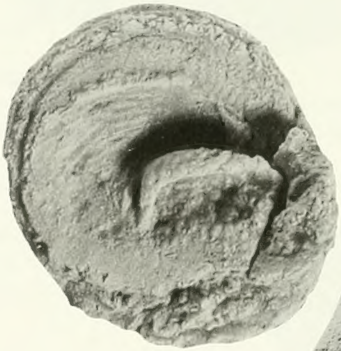
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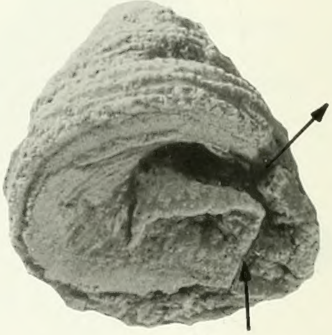
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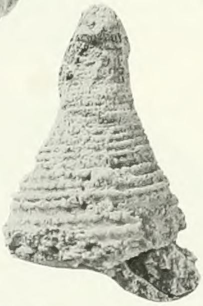
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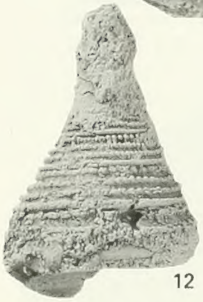
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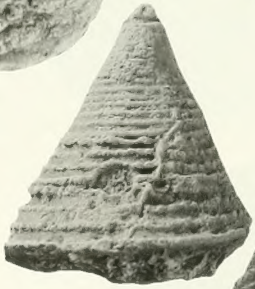
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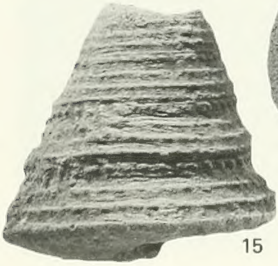
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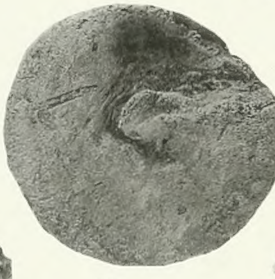
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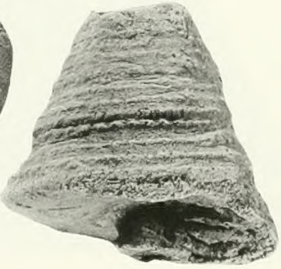
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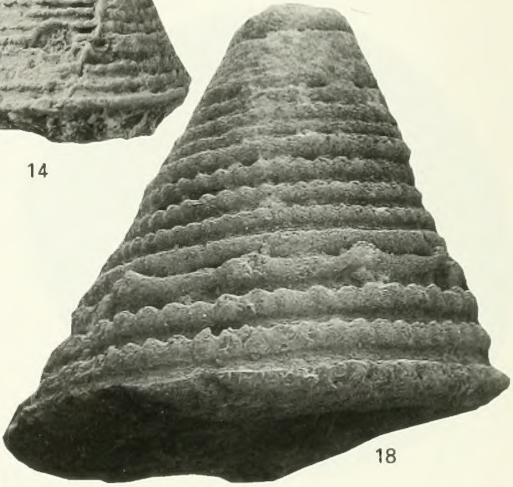
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STEGNOSTOMELLA AND *TECTUS*

EXPLANATION OF PLATE 18

Figure Page

1–11. ***Stegnostomella haughtonensis*** Sohl, n. sp. 67

1. Side view (×5) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 71 (USGS Mesozoic locality 30000; USNMNH 468176). Note spines on the basal periphery.

2, 9. Back and basal views (×5) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 69 (USGS Mesozoic locality 30429; USNMNH 468177).

3. Back view (×4) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 69 (USGS Mesozoic locality 30429; USNMNH 468178).

4. Back view (×5) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 71 (USGS Mesozoic locality 30000; USNMNH 468179).

5. Basal view (×5) of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 69 (USGS Mesozoic locality 30429; USNMNH 468180).

6. Basal view (×5) of apertural surface of a paratype from Jamaica, Green Island inlier, Green Island Formation, at locality 71 (USGS Mesozoic locality 30000; USNMNH 468181).

7. Basal view (×5) of apertural surface of a paratype from the same locality (USGS Mesozoic locality 30000; USNMNH 468182).

8. Basal view (×5) of apertural surface of a paratype from the same locality (USGS Mesozoic locality 30000; USNMNH 468183).

10, 11. Basal and apertural views (×5) of the holotype from locality 69 (USGS Mesozoic locality 30429; USNMNH 468175). Arrows on figure 11 indicate probable directions of inhalent and exhalent currents.

12–18. ***Tectus revesensis*** Sohl, n. sp. 69

12, 13. Back and apertural views (×3) of a paratype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468185).

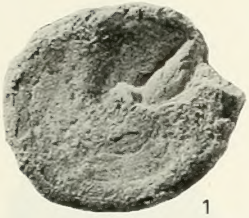
14. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 29365; USNMNH 468186).

15–17. Back, basal, and apertural views (×4) of the holotype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 12 (USGS Mesozoic locality 33364; USNMNH 468184).

18. Back view (SEM ×16) of a paratype from Puerto Rico, Barranquitas quadrangle, Revés Member of the Pozas Formation, at locality 11 (USGS Mesozoic locality 29365; USNMNH 468187).

EXPLANATION OF PLATE 19

Figure		Page
1, 2.	***Tectus berryhilli*** Sohl, n. sp.	69
	Basal and apertural views (×4) of the holotype from Puerto Rico, Central Aguirre quadrangle, Coamo Formation, at locality 2 (USGS Mesozoic locality 26829; USNMNH 468188).	
3–7, 9, 10.	***Tectus*** sp. A	70
	3, 4. Basal and apertural views (×4) of a specimen from Puerto Rico, Sabana Grande quadrangle, El Rayo Formation, at locality 14 (USGS Mesozoic locality 29088; USNMNH 468191).	
	5, 6, 9. Apertural, back, and basal views (×2) of a specimen from the same locality (USGS Mesozoic locality 29361; USNMNH 468192).	
	7. Back view (×2.5) of a specimen from the same locality (USGS Mesozoic locality 29088; USNMNH 468193).	
	10. Back view (×2.5) of a specimen from the same locality (USGS Mesozoic locality 29075; USNMNH 468194).	
8, 11–13.	***Tectus kauffmani*** Sohl, n. sp.	70
	8, 11, 12. Back, apertural, and basal views (×4) of the holotype from Jamaica, Green Island inlier, Green Island Formation, at locality 71 (USGS Mesozoic locality 30000; USNMNH 468189).	
	13. Back view (×4) of a paratype from the same locality (USGS Mesozoic locality 30000; USNMNH 468190).	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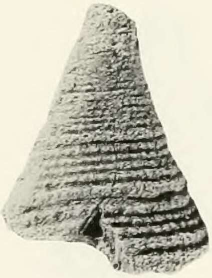
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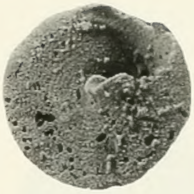
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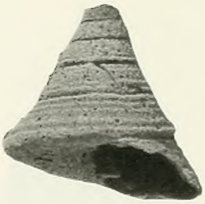
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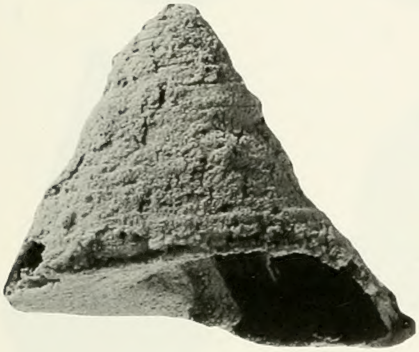
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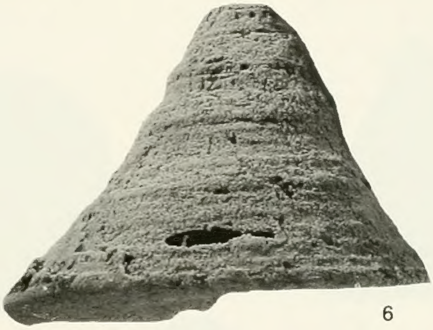
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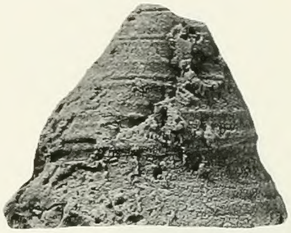
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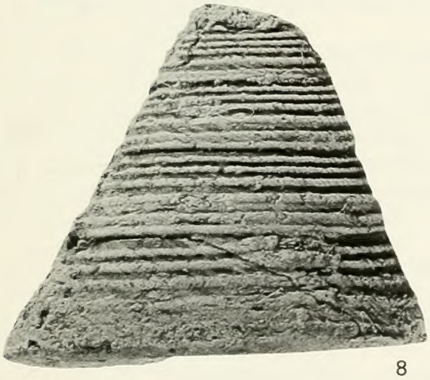
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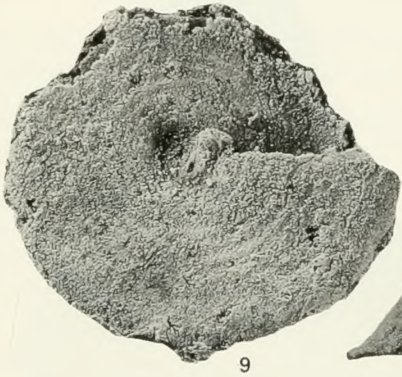
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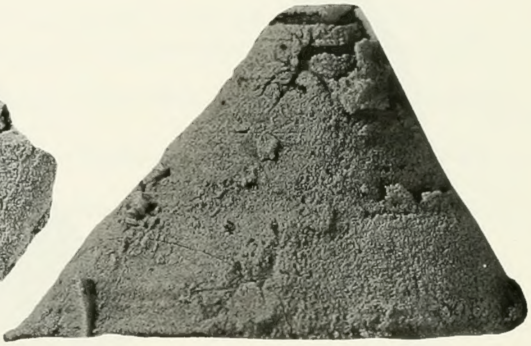
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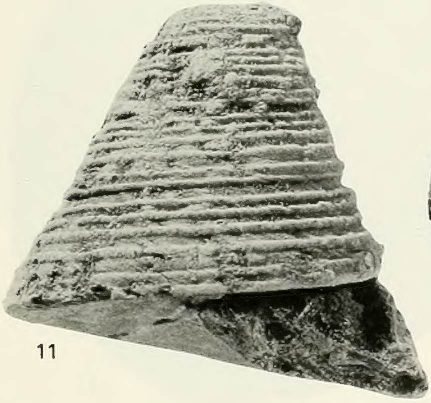
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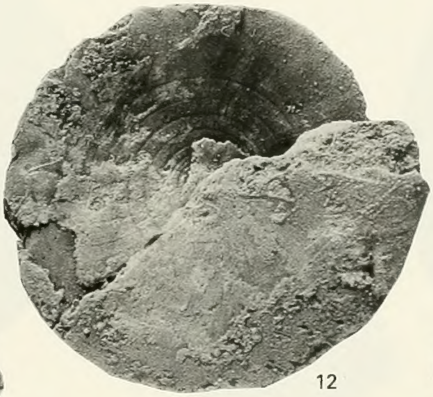
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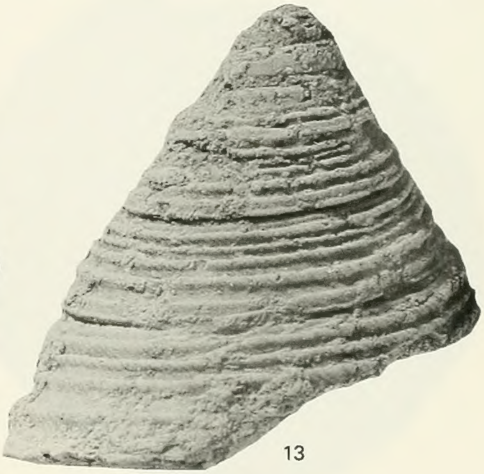
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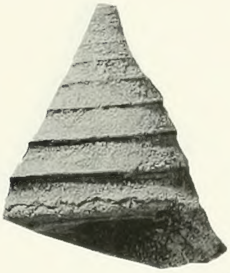
TECTUS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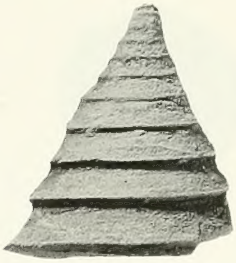
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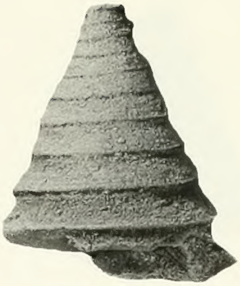
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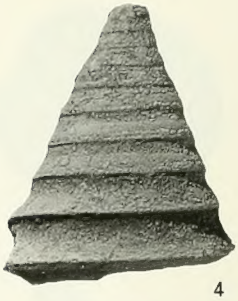
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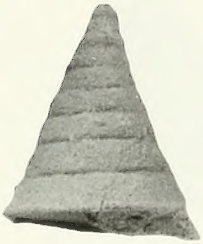
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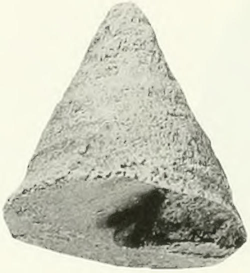
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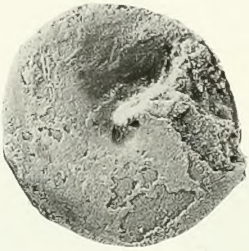
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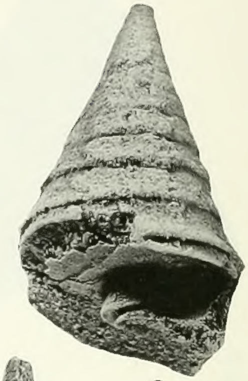
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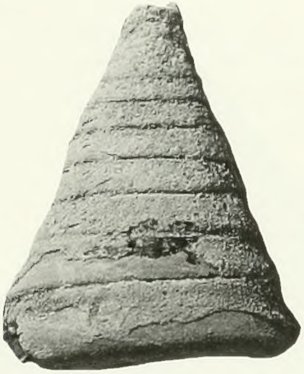
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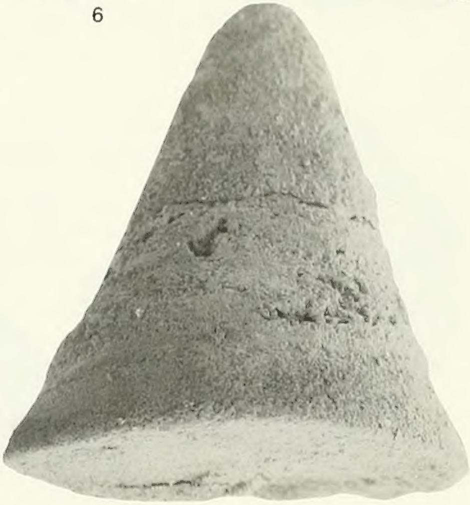
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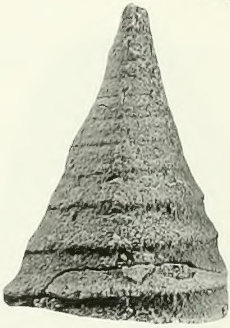
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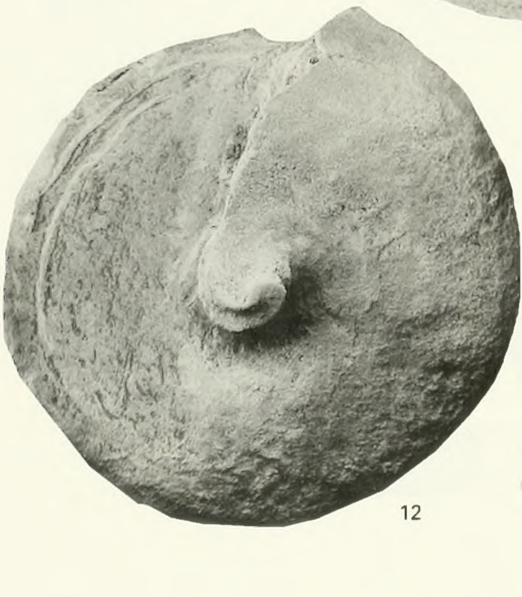
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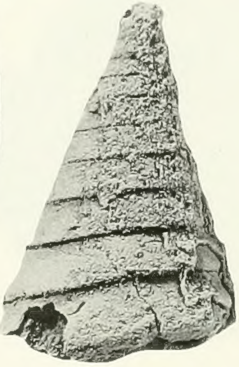
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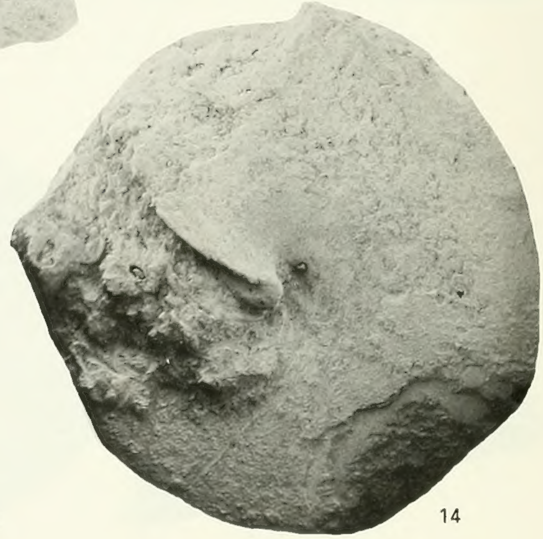
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TECTUS

EXPLANATION OF PLATE 20

Figure Page

1–14. ***Tectus variegatus*** Sohl, n. sp. 71

1, 2. Apertural and back views (×4) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 51 (USGS Mesozoic locality 29925; USNMNH 468196).

3, 4, 7. Apertural, back, and basal views (×4) of the holotype from the same locality (USGS Mesozoic locality 29925; USNMNH 468195).

5. Apertural view (×8) of a paratype from the same locality (USGS Mesozoic locality 29925; USNMNH 468197).

6. Inclined apertural view (×4) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 52 (USGS Mesozoic locality 30030; USNMNH 468198).

8, 11. Inclined apertural and back views (×4) of a paratype from the same locality (USGS Mesozoic locality 30030; USNMNH 468199). Specimen oriented to show twist of columellar base.

9. Back view (×4) of a paratype from Jamaica, Central inlier, Guinea Corn Formation, at locality 41 (USGS Mesozoic locality 30061; USNMNH 468200).

10. Back view (SEM ×30) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 51 (USGS Mesozoic locality 29925; USNMNH 468201).

12. Basal view (SEM ×10) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 52 (USGS Mesozoic locality 30450; USNMNH 468202).

13. Back view (×4) of a paratype from Jamaica, Central inlier, Guinea Corn Formation, at locality 41 (USGS Mesozoic locality 30061; USNMNH 468203).

14. Basal view (SEM ×10) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 52 (USGS Mesozoic locality 30450; USNMNH 468204).

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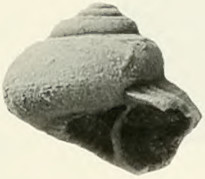
1–7.	***Solariella marchmontensis*** Sohl, n. sp.	73
	1, 2. Apertural and basal views (×5) of the holotype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 65 (USGS Mesozoic locality 30493; USNMNH 468209).	
	3, 4. Apical and back views (×5) of a paratype from the same locality (USGS Mesozoic locality 30493; USNMNH 468210).	
	5. Apical view (×5) of a paratype from the same locality (USGS Mesozoic locality 30493; USNMNH 468211).	
	6. Apical view (SEM ×47) of a paratype from the same locality (USGS Mesozoic locality 30493; USNMNH 468212).	
	7. Apertural view (SEM ×29) of a paratype from the same locality (USGS Mesozoic locality 30493; USNMNH 468213).	
8–14.	***Jujbinas botijasensis*** Sohl, n. sp.	72
	8. Back view (×5) of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 5 (USGS Mesozoic locality 31489; USNMNH 468206).	
	9. Interior view (SEM ×14) of a fragment of a body whorl of a paratype from Puerto Rico, Barranquitas quadrangle, Botijas Limestone Member of the Pozas Formation, at locality 4 (USGS Mesozoic locality 26802; USNMNH 468207). Arrow points to edge of the outer lip. Note ridges on interior surface.	
	10, 13, 14. Back view (×5), back sculpture detail (SEM ×38), and enlarged back view (SEM ×13) of the holotype from the same locality (USGS Mesozoic locality 26802; USNMNH 468205).	
	11, 12. Apertural views (×5, SEM ×15) of a paratype from the same locality (USGS Mesozoic locality 26802; USNMNH 468208). Arrow on figure 12 points to low denticle on the columella.	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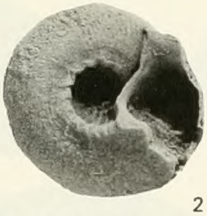
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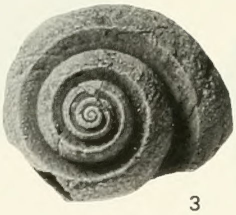
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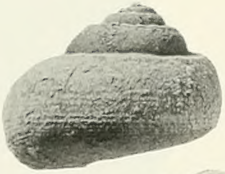
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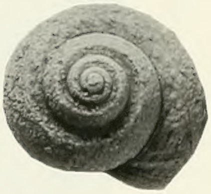
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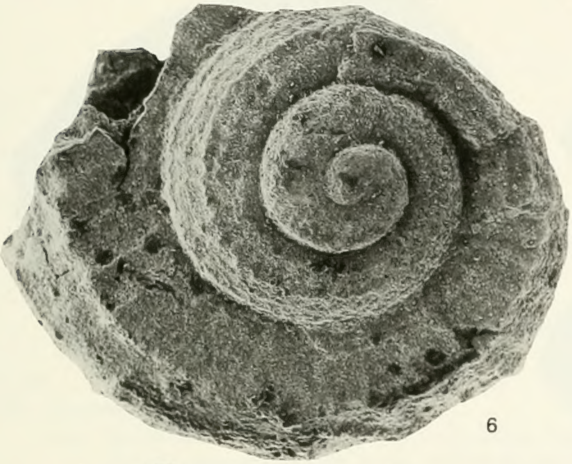
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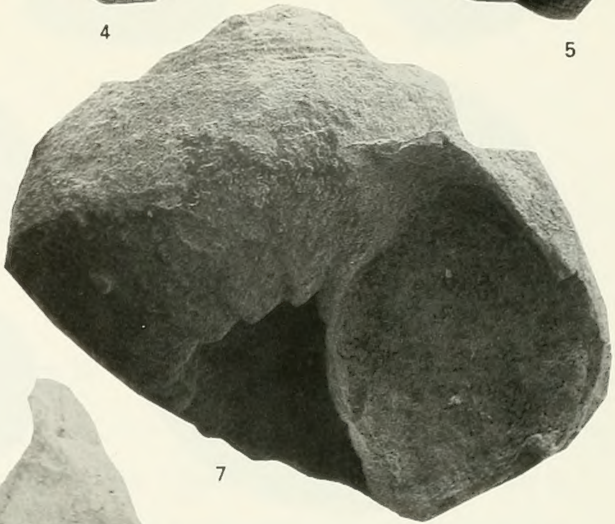
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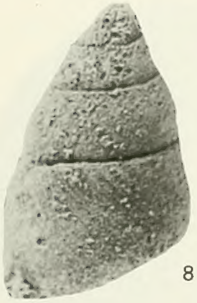
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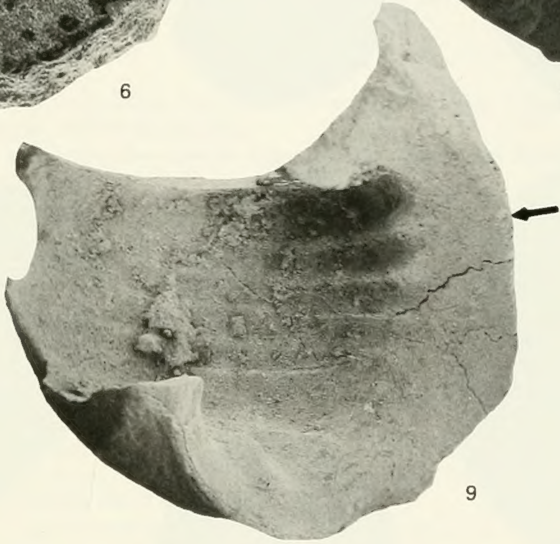
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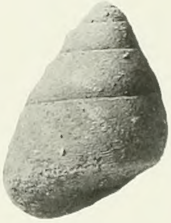
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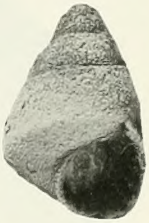
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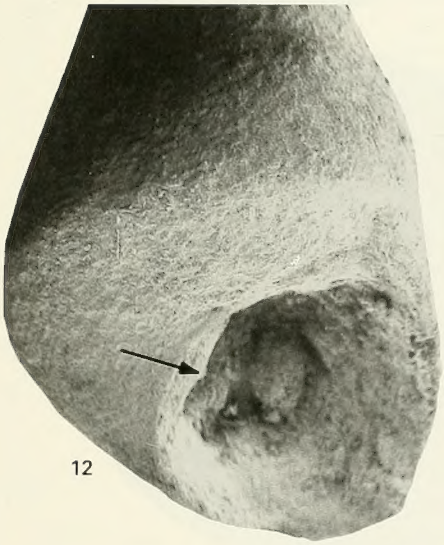
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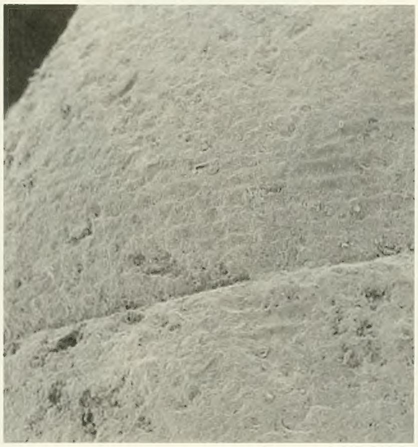
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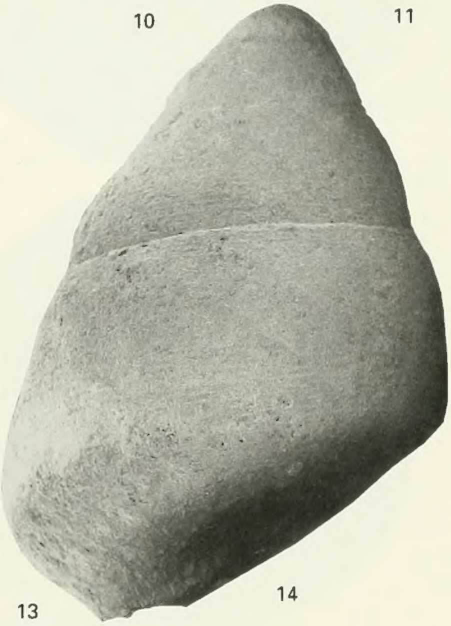
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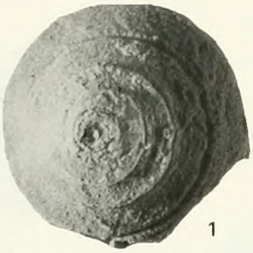
SOLARIELLA AND *JUJUBINUS*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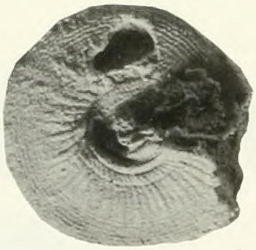
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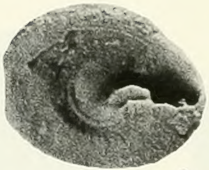
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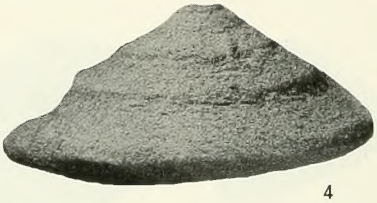
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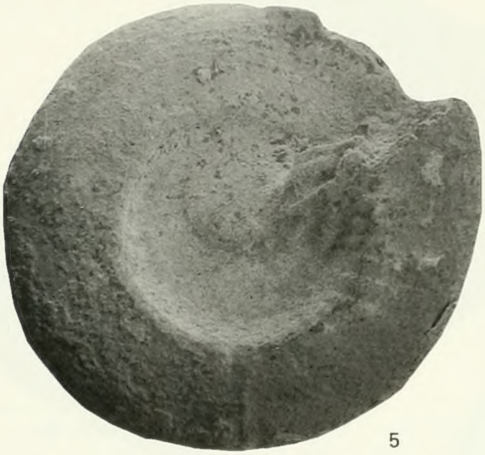
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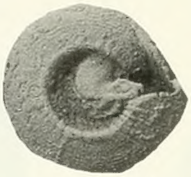
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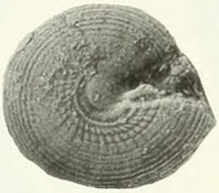
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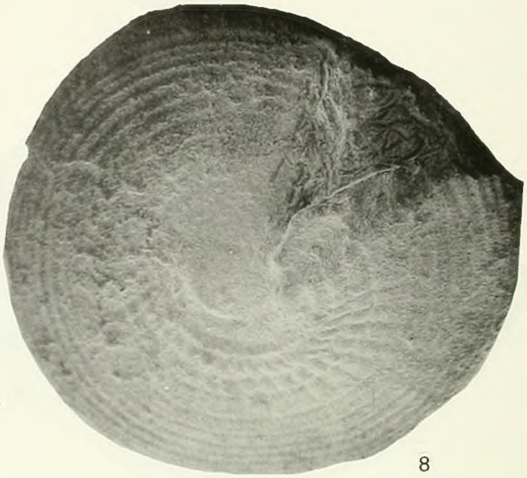
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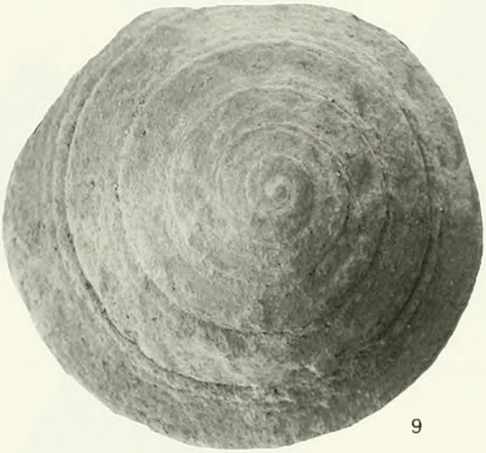
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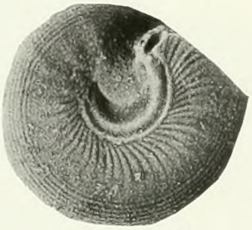
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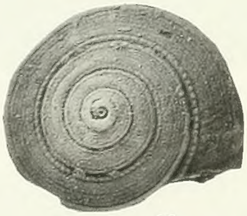
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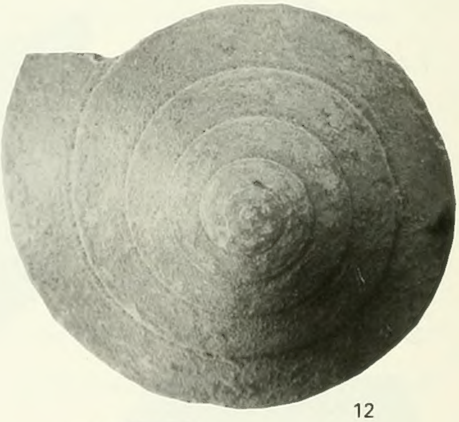
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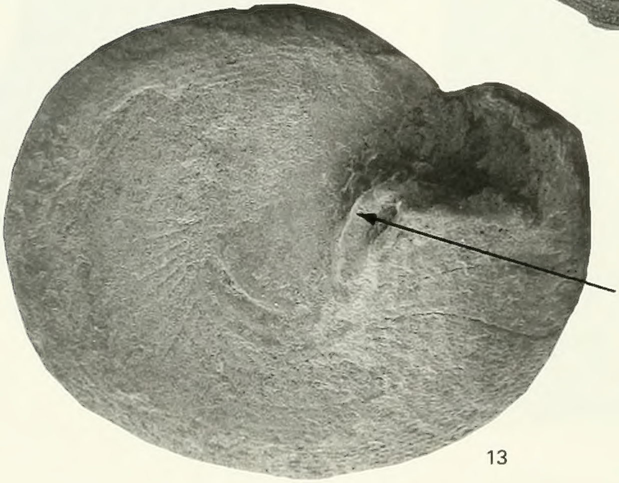
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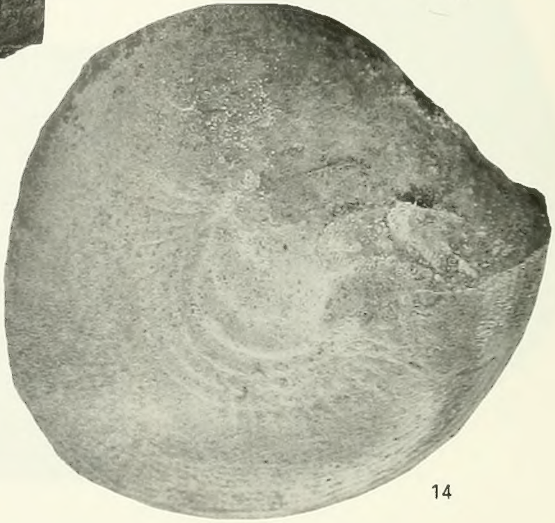
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CAMITIA (MICATIA)

EXPLANATION OF PLATE 22

Figure Page

1–14. ***Camitia (Micatia) plicata*** Sohl, n. sp. 74

1, 2. Apical and basal views (×5) of the holotype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 63 (USGS Mesozoic locality 31367; USNMNH 468214).

3. Oblique basal view (×8) of a paratype from Jamaica, Central inlier, Guinea Corn Formation, at locality 43 (USGS Mesozoic locality 30040; USNMNH 468215).

4. Back view (×8) of a paratype from the same locality (USGS Mesozoic locality 30040; USNMNH 468216).

5, 6. Basal views (SEM ×15, ×6) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 63 (USGS Mesozoic locality 31367; USNMNH 468217).

7, 8. Basal views (×6, SEM ×11) of a paratype from Jamaica, Central inlier, Guinea Corn Formation, at locality 43 (USGS Mesozoic locality 30040; USNMNH 468218).

9. Apical view (SEM ×18) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 63 (USGS Mesozoic locality 31367; USNMNH 468219).

10. Basal view (×6) of a paratype from Jamaica, Central inlier, Guinea Corn Formation, at locality 43 (USGS Mesozoic locality 30040; USNMNH 468220).

11. Apical view (×6) of a paratype from the same locality (USGS Mesozoic locality 30040; USNMNH 468221).

12. Apical view (SEM ×12) of a paratype from Jamaica, Marchmont inlier, "Titanosarcolites limestone," at locality 64 (USGS Mesozoic locality 30491; USNMNH 468222).

13. Basal view (SEM ×13) of a paratype from the same locality (USGS Mesozoic locality 30491; USNMNH 468223). Arrow points to edge of columellar plication.

14. Basal view (SEM ×12) of a paratype from the same locality (USGS Mesozoic locality 30491; USNMNH 468224).

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